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Grant/Contract Closeout Actions Remaining:

x Final Invoice ~~and Closing Documents~~
_ Final Fiscal Report
_ Final Report of Inventions
_ Govt. Property Inventory & Related Certificate
_ Classified Material Certificate
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D-48-630

VALUE ENGINEERING IN CONSTRUCTION

THREE CASE STUDIES

Prepared for:

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ARCHITECTURE
ATLANTA, GEORGIA 30332

1979

VALUE ENGINEERING IN CONSTRUCTION

THREE CASE STUDIES

Prepared for:

Environmental Protection Agency

General Services Administration

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June, 1979

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VALUE ENGINEERING IN CONSTRUCTION
THREE CASE STUDIES

Introduction

The importance of value engineering (VE) as a means to reduce costs and improve the performance of constructed facilities has increased steadily since its development as a formal practice in the years following World War II. It is now used by a number of agencies of the Federal government, and is specified in major design and construction contracts by both the Environmental Protection Agency (EPA) and the General Services Administration (GSA). An example of its value is the experience of the Southeastern Region of EPA where cost savings of $40 millions or 10% of approximately $400 millions in construction contracts were realized through value engineering design changes in thirteen projects.

Given the magnitude of such cost reductions, but with no reduction in quality and improvements in performance that can result from value engineering, the VE process has begun to receive considerable attention. With the aim to enlarge its application and refine its techniques, EPA and GSA jointly commissioned the College of Architecture of the Georgia Institute of Technology to do a series of case studies of value engineering efforts in construction projects for their agencies. This report summarizes the first three of these case studies. They are: (1) Federal Office Building, Jackson, Mississippi; (2) Federal Building and U.S. Courthouse, Fort Lauderdale, Florida; and Case Study (3) McAlpine Wastewater Treatment Plant, Charlotte, North Carolina.

The case studies were developed primarily from data supplied by EPA and GSA. They consisted of the final reports and working data from value engineering workshops that were conducted for each construction project. In addition, meetings and telephone discussions were held with principals in each workshop. Each of the case studies is presented in a narrative describing the sequence of activities in forming and conducting workshops at the site of the construction project addressed, and include both a description of the workshop activities and results achieved. Following the narratives is a summary section in which various aspects in the workshops that appear to have special merit in advancing the value engineering process are identified.

These case studies presume that the reader is generally familiar with value engineering. Thus, a step by step description of the VE process is not reported; rather, exceptions to practice or other unusual events are noted. For those who are unfamiliar with value engineering methodology, EPA publication 430/9-76-008, "Value Engineering Workbook for Construction Grant Projects" is recommended. Excerpts from the worksnop report for the Federal Office Building in Jackson, Mississippi are given in the Appendix to provide examples of typical schedules and worksheets used in VE studies.

Case Studies

Case Study 1: Federal Office Building, Jackson, Mississippi

The Federal Office Building in Jackson, Mississippi is a monolithic cast in place concrete building of 396,804 square feet. It has fifteen stories above surface and one basement floor. It is finished with decorative facing and is serviced by variable air volume cooling and heating with underfloor raceways for power and telephone. The cost of its construction as shown in the final workshop report of the value engineering consultant was $19,413,132.

The building was designed by Barlow and Plunkett, Architects and Engineers, Jackson, Mississippi, and constructed under a construction management contract with Algernon Blair, Inc., Montgomery, Alabama. Overall construction control was the GSA Region 4, Atlanta, Georgia. Value Engineering Company, Alexandria, Virginia, was retained by Algernon Blair to conduct the value engineering study.

The retention of a consultant firm for value engineering services followed conventional practice under GSA Construction management contracts in which the construction manager is required to have an independent value engineering analysis made of the design of the building at a point approximately 90-95% through the design concept phase. The selection of Value Engineering Company was on the basis of competitive proposals submitted to Algernon Blair and approved by GSA.

The value engineering study consisted of a forty-hour workshop conducted over a five day period from January 5 through 9, 1976 in meeting rooms at the Hilton Hotel in Jackson, Mississippi. Both the forty-hour workshop and the use of public meeting rooms are common practices to make the best use of participants' time and to gain the advantages of undisturbed space away from the demands of the participants' places of business.

The workshop was conducted by a two-man team of trained specialists from Value Engineering Company. A total of 21 persons participated in four study teams corresponding to pre-determined cost elements of the building and according to professional disciplines.

The mission for the workshop was to generally evaluate the cost of the proposed design of the building and identify specific areas where substantial savings could be achieved. The study was conducted at the design stage where fairly detailed but still preliminary construction drawings and specifications had been prepared. At this stage, the concept for the building was firm and the architectural program - or performance requirements - known, but final design considerations and construction procedure remained to be resolved. At this stage the VE process is most effective as the means to evaluate the design in considerable detail, and options to modify the design are open. Following the VE study, the design architects and construction managers are in a position to evaluate the VE recommendations and make necessary design changes. The design is then resolved and final drawings and documents prepared for the construction phase to follow.

The workshop teams and participating disciplines were:

Team 1.

Mechanical Systems (includes HVAC, plumbing, fire protection) 5 participants	Mechanical Engineer Project Superintendent Electrical Technicial Building Manager GSA

Team 2.

Structural and Exterior Wall (includes foundation, fenestration, excavation) 6 participants	Project Architect Structural Engineer Construction Executive Construction Estimator Project Director GSA

Team 3.

Interior Construction and Roof (includes finishes and floor system) 5 participants	Construction Estimator Construction Manager Project Manager Mechanical Engineer GSA

Team 4.

Electrical (includes service, distribution, lighting, and power) 5 participants	Electrical Engineer Chief Construction Engineer Scheduling Consultant Assignment and Utilization Specialist GSA

All arrangements for the workshops and the selection of the individuals and disciplines making up the teams were made by Algernon Blair following recommendations from Value Engineering Company. The teams were drawn from the construction management firm, the GSA, the design architect and engineering firm, and subcontractors to the project. The make-up of the teams was such as to provide both a diversity of disciplines and specialized expertise. An attempt was made to distribute individuals from the same organization among the teams to help ensure objectivity.

Two major activities of approximately equal time were performed in the workshop. These were the familiarization and training of participants in value engineering theory and workshop techniques, and value engineering analyses for each of the study areas.

The training activity is of special note because not all participants were familiar with value engineering methodology and without a common basis to conduct the analyses, the process would be of little value. This condition has been common in value engineering workshops and may be expected to occupy a considerable portion of workshop time until the value engineering process becomes a routine part of engineering, architecture, and construction management education and professional practice.

General materials for the workshop were provided by Algernon Blair, Inc., from a list supplied by Value Engineering Company. They included working drawings, construction schedules, notebooks, and the like. Working documents such as cost models, value engineering instructional booklets and similar special materials used for the VE analyses were supplied directly by Value Engineering Company.

The workshop schedule was prepared by Value Engineering Company. A tentative schedule covering all five days of the workshop, proposed studies to be undertaken in the workshop, and the program of familiarization and instruction was provided to Algernon-Blair, Inc., and forwarded to GSA for approval approximately three weeks before the workshop was convened.

The development of the schedule and preparation of workshop materials was accomplished in a specified planning period of approximately four weeks immediately before the convening of the workshop. During this period, the Value Engineering Company workshop leaders familiarized themselves with the construction project from design drawings provided by Algernon-Blair, Inc. and prepared the cost models and other special documents used in the workshops. The key effort in this period was the selection of the four study areas for the workshop. These were determined by Value Engineering Company from their analysis of the design drawings and discussions with the construction manager. Also in this period, GSA was informed of the preparations for comment and approval. GSA's representative in this planning phase was a staff member of the Special Projects Office in Region 4, who served as project director in charge of construction contracts, schedules, and the like for the project. This procedure of having one individual follow a project through the construction activity including the value engineering analysis is formalized as Value Management in GSA. It adds greatly to the continuity of the project and generally works to expedite any change orders that may arise from the value engineering effort.

The planning and setting up of the workshop, selection of participants, and other general procedures followed guidelines set forth in GSA Value Engineering Handbook, PBS, p. 8000.1.

The value engineering workshop was convened on January 5, 1976. It was initiated with an informal get together the evening before of all participants, to introduce themselves and develop bases for the work that would cover the next five days. The workshop followed the schedule given in the Appendix. The two functions of training in value engineering techniques and project analysis were combined throughout the workshop sessions.

The workshop was organized around a basic document, the "Value Engineering Workbook", prepared by Value Engineering Company expressly for the workshop. A copy used in the workshop is provided in the Appendix. The workbook provided a general cost model which each workshop team used to determine overall cost factors and to reference relationships to the areas the other teams were examining, and included worksheets covering the information phase, functional analysis, graphical analysis, creative idea development, idea evaluation, the weighting of constraints, cost breakdowns, life cycle costing, and the writing of the proposals for design changes resulting from the study.

Each team used the workbook to cover its assigned study area. Workshop sessions began with general discussions and training lectures on the techniques used in the analyses and covered specific worksheets. The teams then applied what was thus learned to their individual areas using the supplied data and developing their analyses. This procedure was followed methodically through the fourth day of the workshop, at which point proposals for design changes derived from the value engineering analyses were drawn up for presentation to the group on the fifth and final workshop day. Upon completion of the workshop, Value Engineering Company retrieved all working documents, analyses, and change proposals for preparation of a final report which was subsequently completed and delivered to Algernon-Blair, Inc., in fulfillment of contract obligations. Algernon-Blair was then left with the responsibility to review the final report recommendations and make the appropriate design changes with the concurrence of GSA.

At the beginning of the workshop, a general familiarization of the workshop participants with the workshop schedule and general value engineering procedures was made, and the four study teams were formed based on an overall appraisal by the group of the major cost and performance areas of the building. Because of the limitations of time, the selection of study areas was led by the Value Engineering Company workshop leaders based on their prior analysis of the building. Each team then undertook independent investigations joining together with the other teams for general discussions, familiarization and training sessions, and the presentation of findings. All work was accomplished in the same meeting room. Brief summaries of the work of each team as presented in the final workshop report is given below.

Team 1 concentrated on the HVAC (heating, cooling, and air conditioning) and plumbing systems. The bases of examination and findings were as follows.*

> "HVAC - The original system was a variable air volume (VAV) system in the interior spaces providing a reasonably priced scheme for good cooling control with reduced fan HP and load diversity."
>
> "Hot water perimeter heating provides minimum energy usage when supplied with heat rejected from the chilled water machinery."
>
> "Double bundle water chilling equipment provides simultaneous heating and cooling for the same energy input."
>
> "Economizer cycle and auxiliary heating maintains control of low temperatures."

---

*Paragraphs distinguished by quotation marks are taken verbatum from workshop final report.

"It was proposed that the VAV system in the interior spaces function as in the Basic System."

"Perimeter heating system changes from hot water radiation to direct distribution of interior heat to the perimeter by overhead ducts resulting in equipment and maintenance cost savings with insignificant increase in energy use."

"Double bundle chillers are replaced with standard chillers at lower cost with insignificant change in energy use."

"Economizer cycle provides economical cooling at low temperatures. Electric coils in perimeter heating units use energy only at very low temperatures."

Instant Savings	$327,209
LCC* Annual Savings	$ 68,121

"Plumbing - The original plumbing system required that roof drains be cast iron and that all domestic cold water piping be insulated. The domestic hot water was to be a hot water heater with return line pumps."

"It was recommended that PVC pipe be used for the roof drain risers only and that any horizontal vans remain cast iron. It is also recommended that all domestic cold water pipe in chases not insulated as condensation is no real problem in these areas. The system for domestic hot water is recommended to be a hot water heater at each floor without recirculation."

Instant Savings	$45,446
LCC Annual Savings	$ 3,679

Team 1 followed conventional value engineering procedures identifying the principal functions of the systems they examined and evaluating a number of alternate means to perform these functions. In the HVAC study, 24 creative ideas were reduced through the weighted constraint analysis to seven alternatives including the original design. Of these, four were shown to be analyzed for first cost advantages, and two alternatives and the original design were subjected to life cycle cost evaluations. From these cost analyses, one alternative was selected based on savings in both initial and life cycle costs. A schematic diagram of the proposed alternative was prepared in addition to the cost analyses to guide re-design efforts.

In the plumbing study, plumbing and fire protection were combined as having the common function of distributing fluids. Fifteen ideas were developed

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*Life Cycle Costs

of which five were selected for cost analysis. The selected alternative indicated savings in both initial and life cycle cost areas.

Team 2: Structural and Exterior Wall

Team 2 examined the superstructure, foundation, earthwork for site preparation, vertical transportation system, parapet wall, and exterior wall in separate analyses. With the exception of the parapet and exterior walls, the cost advantages of alternatives proved to be minimal, not necessitating a change, or some overriding condition such as externally imposed codes (e.g., GSA elevator specifications) justified the original design. The bases of examination and findings for the remaining two study areas where changes were proposed are:

"Exterior Wall - The original concept was face brick with some sort of backup; either block or metal studs. The alternate proposal was a precast concrete exterior with a backup. The VE study indicated the alternate was the preferred system. It was recognized that possible inadequacies in the available cost information existed. However, it was recommended that precast concrete be strongly considered."

Instant Savings	$226,422
LCC Annual Savings	$ 23,153

"Parapet Wall - The original scheme had brick and block parapet wall to hide penthouse clad with metal panels. It was recommended to remove the parapet wall and use brick on the penthouse wall."

Instant Savings	$129,680
LCC Annual Savings	$ 13,761

Team 3: Interior Construction

Team 3 followed similar analytical procedures as Teams 1 and 2, but in addition, developed an independent cost-worth model using the format given in the workbook. Following this model, Team 3 examined the roof system, partitions, ceiling, and flooring. Each analysis was carried to the point of cost evaluation. The flooring system only was judged to have potential for improvement and an alternative selected. The basis for this conclusion and the results of the analysis are:

"Floor System - The as designated floor system consisted of a two level duct system in the concrete slab. A raised access floor system on a structural concrete slab was recommended. Initial cost savings were identified as well as decreased construction time. Operating costs were lowered and maintenance cost increased only slightly."

Instant Savings $ 37,551

LCC Annual Savings $ 41,106

Team 4: Electrical

Team 4 also developed a cost-worth model. Its analysis using this model broke down the electrical study area into service and distribution, lighting and power, special systems and emergency power. The procedure followed used conventional functional analysis, weighted constraints, and cost estimating but differed in that the four elements shown in the model were combined into a single distribution system. This then allowed the analysis to concentrate on alternatives to this overall system rather than dealing with separate component parts. This examination and its findings are:

"Electrical (Alternate #2) - The original cost estimate included a double duct embedded underfloor system for telephone and electric services at a cost of $362,400. If an access floor system alternate is accepted, it will be necessary to provide a home run conduit and junction boxes at a cost of $108,025, which would result in a net deduction of $254,375 for this electrical alternate."

Instant Savings $254,375

LCC Annual Savings $ 26,012

"Electrical (Alternate #3) - The original cost savings estimate was based on the use of two 2000 KVA power transformers. Actual VE design analysis indicated that the use of three 1000 KVA transformers with three 15 KV primary feeders will satisfy the power requirements at a savings of $19,063."

Instant Savings $ 19,063

LCC Annual Savings $ 7,548

"Electrical (Alternate #5) - This alternate considers the elimination of the emergency generator at an instant initial cost saving of $38,000. The team reviewed the proposed use of three 15 KV feeders supplied from three separate substations by diverse underground routes, with three power transformers in a spot network configuration with network protectors. This led to the conclusion that a very high reliability of service would result. The loss of one primary feeder would permit uninterrupted service with adequate capacity to serve the building. Under the remote possibility of the loss of a second primary feeder, adequate capacity is available to evacuate the building (with elevators) if required, because the 2 elevator banks are fed by separate sections of the main bus. The team was aware that this deviation from GSA criteria is not normally acceptable; however, the proposed design provides the equivalent of 3 separate primary feeder services and exceeded the team's interpretation of the NEC (Natural Electircal Code) requirement for two separate supply sources."

Instant Savings	$ 38,000
LCC Annual Savings	$ 3,886
TOTAL Instant Savings	$1,151,557
TOTAL LCC Annual Savings	$ 189,211

The $1,151,577 total instant savings is 6.6% of the construction cost.

With the completion of these analyses, each team reported their findings to the overall group and made note of other areas of potential cost savings that either could not be covered in the allotted workshop time, or for which data was not available. These areas were developed on separate worksheets and indicated in the final workshop report as follows:

Other Areas with Potential Savings:

Team 2: It appeared that LCC favored split elevator system (4 plus 4) over the 8 full height elevator system.

Cost of 8 full height system	$1,160,000
Cost of split system (4 + 4)	943,000
Initial savings	207,000
LCC Annual Savings	31,113

Areas Suggested for Further Study

Team 2:
- a. Operating versus fixed windows.
- b. Half basement in lieu of full basement.
- c. Eliminate basement.
- d. Study stell framing system over the less expensive concrete system with regard to construction time.
- e. Background masking system versus noise from AC system.

The workshop concluded on the fifth day with the presentation of study findings and a summary discussion of the workshop by all participants. Certificates of participation were distributed to each workshop attendee.

Case Study 2: Federal Office Building and U.S. Courthouse, Fort Lauderdale, Florida

The building housing Federal offices and court facilities in Fort Lauderdale is of ribbed cast-in-place concrete panels and glass curtainwalls. It is a four story low-rise complex making extensive use of covered terraces and open areas in keeping with its locale. Parking for 235 cars is provided in a below grade garage. The total gross area for the building and parking facilities is 326,039 square feet of which 164,000 square feet is enclosed and serviced by HVAC. Of this space, 141,530 square feet is for offices and court functions. 76,900 square feet of the total gross area is for exterior terraces, corridors, and general circulation. As a result of the value engineering study, changes in the structural system were recommended that eliminated the structural concept but retained the essential building appearance and space allocations. The total cost for construction was shown in the value engineering workshop report to be $12,974,757 or $56.31 per square foot.

The design architects were William Morgan Architects, P.A., in joint venture with H.J. Ross Associates, Inc. Construction managers for the building were the H.C. Beck Co., General Contractors, Dallas, Texas under overall control of GSA Region 4, Atlanta, Georgia. Value Engineering Company, Alexandria, Virginia, conducted the value engineering workshop under contract to H.C. Beck Co. in accordance with GSA procedures.

The method used by Value Engineering Co. was the same as that used in Case Study 2, the Federal Office Building in Jackson, Mississippi and is, therefore, not described here. It employed a similar 40 hour workshop scheduled at the same stage in the design process, and was based on cost models prepared in advance by Value Engineering Co., and building plans and specifications furnished by the Architect. Workshop participation was by a multi-disciplinary team drawn from GSA and the Contractors and Architects.

The workshop was structured around three cost areas that were examined by separate teams. The teams and the affiliation of their participants were:

Team 1:	Structural Systems 6 participants	General Contractor (2) Architect (1) GSA (3)
Team 2:	Mechanical Systems 6 participants	General Contractor (2) Mechanical Contractor (1) Architect (2) GSA (1)
Team 3:	Electrical Systems 5 participants	Architect (1) General Contractor (1) Electrical Contractor (1) GSA (2)

The fact that the workshop method and value engineering consultant were the same as the Jackson, Mississippi project is useful in that it allows for an evaluation of method in dissimilar projects. The results of the workshop seems to confirm the general utility of the method in producing straightforward analyses with fairly substantial cost savings. Both projects, however, show that the method also limits results to initially determined cost areas and do not provide much lattitude to uncover hidden costs.

The differences in the two workshops rests essentially in their appraoch. The cost modeling of the Fort Lauderdale project was based on square foot cost approximations for three different areas of the building rather than on the single model used in Jackson. The three are the Rated Gross Area (230,400 sq. ft. at $56.31), the Structural Slab Area (294,850 sq. ft. at $16.07), and the Enclosed Area (163,360 sq. ft. at $22.89). This division of total costs into three categories was done because of the significant design differences in enclosed verses open areas of the building. It is a valuable distinction because it provided a more accurate basis to model costs than the use of one average cost when there were gross design differences.

The value engineering teams results as summarized in the workshop report are as follows:

> "The structural system utilized a 'tree' concept. This structure became an integral part of the interior ceiling system. The exterior walls were ribbed-formed cast-in-place (CIP) concrete. A glass window wall is utilized in areas adjacent to the terraces."
>
> "The structural team's VE proposals reflected savings in both the superstructure and exterior CIP wall. The proposal for the superstructure changed from the CIP concrete "tree" system to a flat slab with the interior coffers simulated from sheet rock construction and exterior coffers simulated from stucco construction. The results are as follows:

Initial Savings	$773,000
LCC Annual Savings	59,233
Percent Savings LCC	21.1%

> "Split face concrete masonry units were proposed for the exterior wall. This system would have lower installation cost with less erection time. The findings were:

Initial Savings	$373,990
LCC Annual Savings	32,738
Percent Savings LCC	74.4%

"The mechanical system is described in an outline specification. The chillers and cooling tower are located on the fourth floor. The air handling units are distributed throughout the building. The sprinkler system covers all the enclosed area. There are no sprinklers in the parking area."

"The air distribution was the high cost area in the HVAC system. The original 'tree' system required two block-outs in each dome for diffusers. This proposal replaces these diffusers with a liner diffuser in the lower chase ceiling. The savings were:

Initial Savings	$62,496
LCC Annual Savings	5,550
Percent Savings LCC	8.5%

"The toilet rooms did not have a common wall and were scattered on the floors. If the space requirement would allow the toilet rooms to be stacked and have a common wall, the outcome would be:

Initial Savings	$16,580
LCC Annual Savings	1,470
Percent Savings LCC	4.0%

"The lavatories are planned with hot and cold water. The water in the Fort Lauderdale area has a minimum temperature of 70° F. Team 2 proposed that the hot water be deleted from the lavatories. The initial savings are small compared with the maintenance and replacement savings. The present worth of the Life Cycle Cost annual savings was $53,441. The other savings were:

Initial Savings	$14,600
LCC Annual Savings	4,747
Percent Savings LCC	13.0%

"The present design has large terrace areas within 200 feet of interior spaces. A smoke detector system provides life safety for fire. The building is one foot over the 50 foot height requirement for a sprinkler system. This proposal deletes the sprinkler system. The results were:

Initial Savings	$210,000
LCC Annual Savings	18,660
Percent Savings LCC	67.0%

"The electrical system consists of 480/277 volt 30/4W for light and a power with dry transformers providing 120/280V power for low voltage use. An emergency generator will power for emergency lights, security system and elevators in a power failure."

"The background noise system consisted of an arrangement of speakers and amplifiers to generate a sound to mask conversations. Delete this system completely and let the HVAC system generate the masking noise."

Initial Savings	$66,500
LCC Annual Savings	7,462
Percent Savings LCC	100%

"The system estimated consisted of compression conduit fittings for all conduit 1½" and smaller. Savings would be realized if the use of pressed steel conduit fittings was permitted."

Initial Savings	$3,300
LCC Annual Savings	350
Percent Savings LCC	7.8%

"The electrical system designs included an architectural product system (power), in combination with rigid conduit, flex and junction boxes (telephone). The duplex receptacles and telephone outlets were combination units. This proposal is to use rigid conduit, junction boxes and flex into each 10'0" square with the same combination units as above."

Initial Savings	$24,287
LCC Annual Savings	4,343
Percent Saving LCC	8.0%

"The concept design estimate was based on all copper conductors. This proposal would permit the use of aluminum conductors in wire size #4 AWG and larger."

Initial Savings	$20,000
LCC Annual Savings	2,122
Percent Savings LCC	15.0%

In addition to the changes summarized above, the value engineering review also identified seven areas where it was felt savings may be realized with further study.

Case Study 3: McAlpine Wastewater Treatment Plant

The value engineering study of the McAlpine Creek Wastewater Treatment Plant related to the upgrading and expansion of the plant for the city of Charlotte, North Carolina.

The upgrading was planned in two phases. The initial upgrading will expand the present plant capacity from 10 million gallons of sewage treated per day (mgd) to 20 mgd and will add facilties for biological nitrification for water purification. The second increment will add a further 10 mgd of capacity with nitrification facilities. The total plant capacity upon project completion will be 30 mgd with nirtification facilities.

The design engineers, J. N. Pease Associates forecast a cost for Increment No. 1 for upgrading of $6,155,130, and for Increment No. 2 for expansion of $14,338,700 based on 1974 dollars.

Conduct of VE Studies

Two value engineering workshops were conducted for the project by Stanley Consultants of Muscatine, Iowa. The first workshop was timed to provide input at the 10-30% design completion level. Areas of concern were site arrangement, treatment processes, structural design, and the general electrical and piping systems. The second workshop was concerned with structures not available at the time of the first study, specific electrical and mechanical systems, and chemical feed and instrumentation.

The VE studies were scheduled at step two of EPA's three step design and construction sequence in which step one is the development of a cost effective approach to the facility to be built, step two is the design development phase, and step three is the construction activity. By conducting the VE studies in the middle step both a check on the approach, and the adjustment of the design to construction alternatives is made possible. The completion of step one prior to the VE studies provided fairly detailed schematics of the waste water treatment systems and facilities. A distinction between these studies and the other case studies in this report is that the McAlpine plant represents a construction project which is heavily equipment and process oriented and the building design is minimized. The Jackson and Fort Lauderdale projects conversely are primarily related to building costs. The focus of the McAlpine studies was thus on cost elements with large orders of magnitude with the potential for the revision of whole equipment systems rather than incremental changes.

Each workshop was carried out in two increments--the first being concerned with the upgrading phase of the project and the second with the expansion program.

Each workshop was conducted by a multidisciplined team made up of design professionals drawn from the following areas:

Sanitary Engineering
Civil Engineering
Structural Engineering
Mechanical Engineering
Electrical Engineering
Cost Estimating

The areas of study and the general comments and conclusions of the VE study teams are given below.

First Workshop: Study increment number 1, Upgrading: The following items were selected for study: Structures-Aeration Tanks, Yard Piping, Structures-Sludge Storage Tanks, and Structures-Sludge Transfer Pumphouse. The studies are summarized as follows.

Structures-Aeration Tanks

The aeration tanks were selected because of their high estimated cost. The plant layout shows the new first stage aeration tanks and the second stage aeration tanks located approximately 20 feet apart. A screw lift pump station is being provided to raise the first stage aeration tank effluent for gravity flow through the imtermediate clarifiers and second stage aeration tanks. It was concluded that the two aeration structures could be located side-by-side with a common wall. By combining the two structures, one wall could be eliminated for an initial cost savings of approximately $49,000 or 1.5% of the estimated combined cost of the two structures. This change would have no effect on the operating and maintenance (O&M) costs.

Structures-Yard Piping

The greatest potential for reducing the cost of yard piping was judged to be a change in the arrangement of the facilities to shorten the length of pipe required for interfacing. The site layout proposed by the consultant for the upgrading design was examined and it was concluded that there could be no reduction in pipe length by rearranging facilities, since the arrangement shown by the design consultant is somewhat dictated by the existing facilities.

Structures-Sludge Storage Tanks

Digested sludge is presently stored in two tanks which will be converted to digester tanks as part of the expansion phase. New sludge storage tanks are to be provided and located adjacent to sludge drying beds. Two large concrete storage tanks are included in the design. The VE team considered substituting tanks of equal size and capacity having steel side walls instead of concrete, with a conical concrete bottom retained. In computing the cost of steel tank sides, a high quality epoxy paint applied to grit blasted white metal surfaces was considered for both inside and outside of the tanks. It is expected that this surface treatment would last 10 years. The initial cost savings for this change would be approximately $19,000, representing a 19% cost reduction. This savings would be offset in higher maintanence costs, and a change to steel walls was not considered justified.

Structures-Sludge Transfer Pumphouse

A new sludge transfer pumphouse is contemplated to house the pumps for transfer of sludge from the storage tanks to the drying beds. The basic function of the pumphouse structure is to enclose pumps. The cost-worth ratio of this structure is quite high, and the VE team considered two alternatives; eliminate the building or use a lower cost pre-engineered type enclosure. The original masonry building with concrete roof structure was estimated at $60 per square foot. Weatherproofing of the equipment would be required if the building super-structure was eliminated. This weatherproofing was estimated at $42,000. The elimination of the building will result in an initial savings of approximately $34,000. The cost of a pre-engineered building was estimated at $25 per square foot. Substitution of a pre-engineered building will result in initial cost reduction of approximately $24,000. These savings represent 83% and 58% respectively.

During the workshop oral presentation, at which time these suggestions were made to representatives of the city of Charlotte, design consultants, and the state environmental agency, there was considerable discussion concerning difficulties and cost of maintaining outdoor equipment. Outdoor installations are, however, frequently made in locations having more severe and longer winter seasons than Charlotte. It was concluded that the ultimate decision must be made on the value placed on the convenience for all weather maintenance of having the equipment enclosed.

Study Increment Number 2, Expansion: The following items were selected for VE study: Pumping-Return Sludge Pumping Stations; Pumping-Main Lift Station; Structures-Preliminary Treatment; Structures-Primary Clarifiers; Structures-Activated Sludge (1st and 2nd stages); Equipment-Activated Sludge; Structures-Anaerobic Digestion; and Structures-Sludge Drying Beds.

Pumping-Return Sludge Pumping Stations

The two return sludge pumping stations as presently designed consisting of the typical wetwell-drywell structure housing three sludge pumps, together with piping and metering equipment. A masonry building approximately 30' x 35' is provided over the drywell portion of the structure.

The team considered two alternatives to the design: (1) wetwell installations with vertical pumps; and (2) elimination of the building and installing the pumps outdoors with weatherproofing. Changing the pumping facility structures to wetwell design with vertical pumps results in an estimated cost reduction of $226,200 for the two pumping stations and represents a 67% cost reduction. Changing the pumping facility to wetwell design with vertical pumps and eliminating the building superstructure results in a cost reduction of $346,200 or an 88% reduction.

Pumping-Main Lift Station

The new main lift station is to be similar to the existing pumping station. The existing station is a wetwell-drywell pumping facility housing the main lift pumps together with the associated piping. A masonry building has been provided with stairs and elevators to the various levels of the pumping station.

The team again considered the cost advantages of a wetwell installation with vertical pumps. Reduction in size of the building superstructure was also investigated. Complete elimination of the building was not considered desirable, but reduction of the building size to provide cover for only the electrical equipment required for the large pumps was considered feasible.

Changing the pump station design to a wetwell scheme with vertical pumps results in an estimated cost reduction of $152,200 or 41%. By reducing the size of the building to provide cover for only the electrical equipment, the estimated savings is increased to $184,900 or 50%.

During the oral presentation, the availability of vertical type sewage pumps for wetwell installation of these capacities was questioned. Subsequent investigation by the team has revealed that vertical sewage pumps of appropriate size are available.

Structures-Preliminary Treatment

The existing main pumping station contains, as an integral part of the structure, the preliminary treatment equipment for the present plant. This equipment consists of a fixed bar screen (manually cleaned), mechanical grinding equipment, and grit removal which is located upstream of the main lift pumps. Duplication of this arrangement is planned for the new pumping station except that a mechanical bar screen is contemplated.

The VE team considered relocating the preliminary treatment equipment, except for the mechanical bar screen, from the main pumping station structures to an area near the rimary larifiers. This removes this construction from a rather deep excavation in the flood plain where dewatering would be required during construction. The new location would be downstream of the main pumps and at the top of the process chain. To provide sufficient elevation to accommodate the hydraulic gradient, approximately 15 feet of fill would be required at this location. The mechanical bar screen would remain ahead of the main pumping station. In computing cost differential for this change, a wetwell type main pumping station was assumed, and an additional concrete structure for the mechanical bar screen was included.

The design of the combined main pumping station and preliminary treatment facility as planned by the Design Consultant was not well defined for the VE team, and the details of the proposed separation were not sufficiently refined to permit a detailed cost estimate. The cost estimate for this proposed change is computed on an incremental difference basis which provides an "order of magnitude" estimate of the savings to be expected. It was estimated that cost savings in the order of $98,000 would be realized by relocating the Primary Treatment Facility.

Structure - Primary Clarifiers

The contemplated primary clarifiers are round concrete structures with revolving sludge scrapers similar to the existing clarifiers. In the study of site arrangement, the team observed that by changing to rectangular clarifiers and using common wall design, a considerable savings in site space is obtained. Also, the combined rectangular configuration would provide further space savings during plant expansion.

The estimate of cost reveals that the change to rectangular clarifiers will cost approximately $15,000 more (18%) than the individual round clarifiers. This added cost may very well be justified by the savings in site space and provision for future expansion.

Structures - Activated Sludge

The site plan of first stage activated sludge facilities as proposed consists of rectangular aeration tanks followed by circular intermediate clarifiers located a considerable distance from the aeration tanks. Approximately 1300' of 48" reinforced concrete pipe would be required to hydraulically connect this arrangement.

By changing the arrangement of facilities to provide a "straight line" configuration instead of the original arrangement, the distance between components of the process is reduced, resulting in shorter runs of interfacing piping and reduction in the hydraulic gradient.

The VE team proposed the combination of the first stage aeration tanks and intermediate clarifiers into one structure. While the cost of the combined structure is slightly greater than that of individual structures, the resulting reduction of interface piping and hydraulic gradient provides savings.

Additional savings are obtained as well from: (1) elimination of the splitter box at the clarifiers; (2) reduced amount of fill in the area of the Primary Clarifiers and Trickling Filters because of the hydraulic gradient saved in combining structures; and (3) reduced pumping cost because of the hydraulic gradient saved. In computing the savings resulting from reduced fill, only the cost of spreading and compacting was used. These additional savings amount to approximately $30,500. Total estimated savings for this change is $101,000 or 58%.

Equipment - Activated Sludge

The present air supply facility consists of 3 positive displacement blowers housed in a masonry building which has space for 2 additional blowers. Air intake for all blowers is routed through a filter unit also installed in the building. While adequate for the 3 existing blowers, additional air filtering capacity will be required for the 2 additional blowers needed for upgrading.

The VE team noted that while the present air blowers are of the positive displacement type, considerable savings may be experienced through the use of centrifugal blowers.

An extension to the present building to house the new blowers needed for the expansion phase is planned. It was recommended that, rather than extend the present blower building, a new blower facility be considered nearer the new aeration tanks to reduce the amount of air piping required. While interconnection piping between the two blower facilities is desirable, the size of the interconnection could be smaller than the main distribution pipe size.

It was recommended that the new blower facility be constructed with the blowers outdoors, thus eliminating a new blower building or an extension to the existing building.

The elimination of the blower building would result in a cost reduction of $123,000 or 68%.

Structures - Anaerobic Digestion

Two additional digester tanks are to be constructed as part of the plant expansion. These are to match the existing digesters which are 105' diameter concrete tanks with a brick facing.

The VE team originally improperly assigned a function for the brick facing of "enhancing appearance". This in essence assigned a secondary function to the brick facing. It was pointed out in the oral presentation that the brick actually had a basic function of "protecting insulation". The VE team thus judged the $56,000 cost of the brick facing is justified and recommended it be retained.

Structures - Sludge Drying Beds

Sludge drying is presently accomplished by means of air drying on sludge beds. One sludge bed facility 200' wide by 1500' long has been effectively drying the sludge produced by the present treatment plant. Dried sludge is sold commercially and the plant has no problem with disposal.

The existing sludge drying beds have concrete perimeter walls, a concrete center wall the length of the beds, and concrete cross walls to provide areas 100' by approximately 46'. An electrically operated traveling cross conveyor is used for transporting the dried sludge to trucks parked at the side of the drying beds. Dried sludge is loaded onto the conveyor by means of a small end loader which operates in the drying beds. The cross conveyor travels the length of the drying beds on rails mounted on the perimeter walls and the center wall. It is intended that two similar sludge bed facilities will be provided in plant expansion.

The VE team considered eliminating the concrete perimeter and center walls and the cross conveyors, constructing the new beds as earth basins. Concrete cross walls at 46' intervals would be maintained. Ramps would be provided to permit trucks to back into the drying beds for direct loading by an end loader. Concrete driving strips would be provided to prevent damage to the filter media by the trucks. This arrangement provides 32 beds 46' wide by 200' long in each of the two drying areas. Since wet sludge is not expected to flow evenly for more than 100', sludge supply lines down both sides of the basins were retained.

It was also observed that cast-in-place 3' x 5' concrete manholes were contemplated for the drying bed drainage system. It was proposed that these be changed to 4' diameter (or smaller) precast concrete manholes.

Changing the sludge beds to earth basins and eliminating the cross conveyors results in an estimated savings of $521,820 or 34%. Changing the cast-in-place concrete manholes to precast concrete manholes results in an estimated savings of $8,400 or 44%.

Second Workshop: Study Increment No. 1 - Upgrading

The following items were selected for study: Aeration, Aeration Tank Structures, Intermediate Clarifier Structures, Final Clarifier Structures, Sludge Return Pumphouse, and Digested Sludge Storage.

Aeration Equipment

Consideration was given to installing the aeration distribution system fixed to the floor of the aeration tanks, eliminating the above-water air mains and drop piping from the mains to the diffuserheaders. This would require a change of diffusers from the "sock" type now used to a non-clogging diffuser. The non-clogging diffusers now available are virtually maintenance free and practically eliminate the plugging problems experienced with "sock" type diffuser. It is necessary to use non-clogging diffusers if a fixed distribution system is installed. While there is little difference in cost between the "sock" type and non-clogging diffusers, the savings in the distribution system would amount to approximately $110,000.

The team also investigated the elimination of the knee or swivel joints in the air drop pipes if a removable system is retained. Two swivels are required for each drop pipe to provide the means of swinging the diffusers out of the tank for maintenance. Fittings are available for disconnecting the drop pipes from the air main system, permitting the drop pipes to be raised vertically out of the aeration tanks for diffuser maintenance. By changing from swing-out type with swivel joints to lift-out diffuser piping the savings would be approximately $132,000.

Aeration Tank Structures

It was observed that Y walls are planned for all interior walls of the aeration tanks. The outside walls have a similar configuration on the interior side. The Y walls are used primarily to carry the air main and provide access to the diffuser piping. By eliminating the Y configuration of the interior walls not carrying air mains and on the interior side of the outside walls, it is estimated $233,000 can be saved. While elimination of the Y walls eliminates access to the antifoam spray headers, it is suggested that $233,000 is an exceedingly high price to pay for this access, particularly when the antifoam header requires so little in the way of maintenance. A light weight boat was suggested as a reasonable substitute for providing the limited access required by the antifoam header.

Consideration was also given to changing the detail for all aeration tank walls to provide a T section instead of the Y section. In this case, the air mains would be installed under the walkway portion of the T section. The

T section would be provided for the walls carrying the antifoam headers also, thus providing access for the infrequent maintenance of the antifoam headers. The savings anticipated by making this change would be approximately $250,000.

It was suggested that consideration be given to combining the elimination of Y walls and installing a fixed air distribution system on the bottom of the aeration tanks. If a fixed air distribution system is installed, the only need for walkways would be to service the antifoam headers. A T section could be provided for these walls. By combining these cost reducing ideas there would be an approximate savings of $552,000. If the walkways were completely eliminated and antifoam headers serviced by boat, the savings would be $623,000.

Intermediate Clarifier Structures

Four 95' diameter clarifiers have been proposed as part of the upgrading of nitrification equipment. Evaluation operation can be expected from two 135' diameter clarifiers. Some flexibility is sacrificed, and should one clarifier be out of service, the full 20 MGD may be required to pass through the remaining clarifier. The VE study team concluded that this eventually would not seriously effect the effluent quality of the plant. The expected savings for reducing the number of intermediate clarifiers from four to two would be approximately $70,000.

Final Clarifier Structures

Two 125' diameter clarifiers were planned to operate in parallel with four existing final clarifiers. Equivalent operation can be expected from one 175' diameter clarifier. Little loss of flexibility would be realized in this change since the new clarifier would be operating in parallel with the four existing final clarifiers. The savings for reducing the number of final clarifiers from two to one would be approximately $78,000.

Sludge Return Pump House

The VE team accepted the original design recommendation to use vertical wetwell type pumps and recognizes the advantages of not only the dry well installation but also the convenience of having the equipment installed inside a protective building. The team studied several arrangements whereby the cost of the sludge return pump house structure could be reduced and still comply with the original design. Three possible alternatives were investigated.

The first alternative maintains the wet well-dry well concept but eliminates the building superstructure. In this arrangement all equipment is installed in the dry well except the pump motors which present no problem when installed outdoors. This arrangement provides a savings of $18,000.

The second alternative eliminates the wet well. The sludge return pumps would take suction directly from the clarifiers. The telescoping valve and sludge well on each clarifier would be eliminated, and sludge flow would be controlled by manually adjusted control valves. This would require one pump for each clarifier, and this arangement should be considered only if the number of Intermediate Clarifiers is reduced to two. A disadvantage to this arrangement is that operators cannot see the sludge as it is drawn off the clarifiers. This objection is overcome, however, by the fact that a separate pump is installed for each clarifier, and the draw-off rate can be adjusted as desired by the operator. Elimination of the wet well provides a savings of $43,000.

Digested Sludge Storage

The team recommends consideration be given to earth basin storage of sludge. Two rubber-lined earth basins could be provided. The side slope of the earth basins would be greater than the slope of the tank bottom presently being designed. This would provide greater effective sludge storage by eliminating "dead" zones. Cleaning of the basins would be easier than the tanks because of the greater bottom slope. Sludge pumps would be installed in a pit or well to provide positive suction. Substitution of earth basins for the concrete sludge storage tanks would save approximately $197,000.

Study Increment No. 2 - Expansion

The following items have been selected for the VE study: Pump Station Structures, Aeration Equipment, Disinfection Structures, and Alkaline Feed Equipment.

Pump Station Structures

The VE study team concluded significant savings could be realized without serious degradation of the product, if some deletions and changes of materials were made on the main pump station structure. These are as follows:

Delete quarry tile floors	$13,000
Delete ceramic tile walls	31,000
Substitute steel stair in lieu of concrete	6,000
Substitute precast concrete roof in lieu of cast-in-place concrete	9,000

In the oral presentation, the design consultant advised that they had already determined that all the above changes were to be made except substitution of steel stairs in place of the concrete stairs.

The same alternates described in Study Increment No. 1, apply to the sludge return pump houses.

The first alternative which eliminates the building superstructure would result in a cost savings of approximately $36,000.

Alternative No. 2 which deletes the wet well and provides direct pumping from the clarifiers would save approximately $86,000.

The third alternative which requires locating the pump houses in an area lower than the clarifiers and provides a dry well at grade would result in cost savings of approximately $64,000.

If the pump house superstructures are to be retained, it was again recommended that changes of materials be made to delete the quarry tile floors and that steel stairways be substituted for concrete. These changes offer a savings of $9,000.

Aeration Equipment

The studies of this equipment in Increment No. 1 were repeated in Study Increment No. 2. By using non-clogging diffusers and installing a fixed distribution system on the bottom of the aeration tanks, approximately $90,000 was projected to be saved. By eliminating the swivel joints in the drop piping and using a lift-out instead of swing-out system, an $108,000 savings was determined.

As in the case of Study Increment No. 1, the team recommended consideration of combining the elimination of Y walls and the installation of fixed air distribution system. By providing T walls for the antifoam headers only and installing the air distribution system on the tank bottom, the savings was estimated at $440,000. If all T and Y walls are deleted and the antifoam headers serviced by boat, the savings would be $510,000.

Disinfection Structures

The study recommendation was that the concrete chlorine contact tank be eliminated and the disinfection system be made a part of the polishing lagoon. A two-cell chlorine contact basin can be constructed at the outlet of the earth basin polishing lagoon by means of interior steel sheet piling and wood baffles. This earth basin arrangement would result in an estimated savings of $90,000.

If it is determined that a concrete chlorine contact tank must be installed, the VE team recommended that the center walkway of the tank be deleted to save $7,000, and concrete block walls be used as baffles instead of cast-in-place concrete for a total savings of $11,000.

Alkaline Feed Equipment

The literature provided the VE team during the information phase of the study indicated that eight package lime silos and feeder units having a lime storage capacity of 3,750 cubic feet each would be installed to serve a design floor of 40 MGD. The same literature indicated that units having 5,000 cubic feet storage capacity are available. By using the larger size unit, the same amount of lime storage can be accommodated in six units for a savings of $300,000. Only four units of the maximum capactiy are needed for 30 MGD. This was estimated to provide a savings of $550,000.

Summary and Comment

The case study examination uncovered a number of significant factors in the methodology that are worthy of comment.

In summary, the workshop process is a fairly standardized operation conducted along specific lines of inquiry. Its objectives are established by the workshop group at large using cost factors and construction data supplied by the building architect and engineer and prepared for the workshop by the independent value engineering consultant. The 40 hour workshop period representing a normal working week was the standard time period. All workshop sessions employed a team approach structured around major cost components of the design. They were held at the construction locale to be close to data services and in independent quarters to reduce the potential for interruptions. Participation in workshop teams was by representatives of the design and construction principles, sub-contractors, and the concerned agencies (EPA and GSA). Independent experts were used in those areas of technical importance not covered "in-house". The general approach and conduct of workshop teams was professional with each member representing his discipline rather than his employer or corporate affiliation. The focus of all workshops was on design rather than construction variables. Because of this, representatives of the architectural and engineering design firms served in advisory capacities on the teams to avoid interest conflicts.

Of special note in the case study review are the following:

1. The workshop process provides a fairly rigorous and disciplined approach to achieve value engineering objectives by the use of standardized work sheets and value engineering forms. These forms direct the value engineering study to specific cost evaluations such as first cost and life cycle costs, but while not excluding more qualitative evaluations, do not provide a ready means to factor qualitative judgements into cost-oriented conclusions. The apparent result is to focus the studies to cost-reduction at perhaps the expense of value-added conclusions. However, life cycle cost analyses, by providing a basis to evaluate operating and maintenance factors over time, provide a means to reconcile intangible performance criteria with cost figures. By emphasizing or expanding this aspect of value engineering methodology, increases in value may well be more effectively appraised.

2. A considerable percentage of workshop time (approaching 30-40%) is spent in familiarizing the participants with the value engineering process. Given the limits of the usual 40 hour session, the amount of time spent in "training" probably detracts seriously from the depth and detail of consideration that can be applied to substantive evaluation. When this time pressure is combined with the workshop's cost orientation, it is obvious that only a few obvious problem categories can be evaluated with the danger that value engineering results may tend toward the superficial.

The EPA has moved to correct this situation by requiring all participants in EPA sponsored workshops to have prior VE training. It would be useful to augment this rule by requiring VE training in architectural, construction, and engineering education as suggested in Case Study No. 1.

3. A considerable number of the workshop participants are provided by the firms involved in the design, construction, or construction management of the projects being evaluated, and usually from those offices that are close to the site. The reason for this is the logical one of saving personnel and travel costs for the construction management firm. The benefit of gaining participants in this manner who are thoroughly familiar with the project is mixed with a probable lessoning of objectivity. An alternative would be to employ only independent experts on the workshop teams with the representatives of the design principles involved in the workshop discussions to provide information only. If this alternative were followed, these experts are best drawn from professionals in the field trained in value engineering and workshop methodologies. This appraoch would also resolve the problem of training time discussed in comment 2 above.

4. The 40 hour workshop session is no doubt adequate to conduct the typical value engineering analysis, especially if some of the suggestions for increasing effectiveness discussed above are followed. However, limiting the evaluation to only this period denies the value engineering process the invaluable benefit of hindsight and second guessing that VE gives the design process. Specifically what is lost is that period of contemplation and rumination that follows workshop participation when ideas of real substance often surface. In addition, as the case studies indicated and the published workshop reports demonstrate, the results are only those reached in the workshop, and of necessity must set aside a number of problem areas for "later study", seven such being identified in the Fort Lauderdale project. There is no indication whether the later study is ever accomplished.

   It is suggested then, that a method be developed for a follow-up appraisal to be made by the value engineering consultant to incorporate any late developing ideas into the final report as well as providing additional insight into set-aside problems. This follow-up appraisal could be telephone interviews or letter surveys of each of the workshop participants conducted in the week after the workshop.

5. The case studies seem to indicate that each workshop is considered a separate and complete entity. No apparent correlation is made between findings nor any organized attempt to transfer knowledge gained in one workshop to another where similar conditions may be evaluated. It would seem worthwhile to institute some formal

procedure of abstracts or other publications where this transfer of knowledge may be accomplished. The extension of this idea may be a central clearing-house or center of excellence for both collecting and disseminating information developed in value engineering examinations operated under the broad authority of the Federal government.

6. Each of the case studies showed considerable involvement by EPA or GSA personnel. Aside from workshop leaders, these Federal employees represented the only institutional continuity in the process. The effect of these staff professionals on the process was not clear. What is apparent is that Federal agency participation represents a direct means to improve the effectiveness and efficiency of workshops that could be accomplished by increasing the skill level of agency staff in the value engineering process and certifying workshop specialists. Although Federal employees involved in construction project management are by and large familiar with value engineering workshops through having attended training sessions, their level of familiarity may be presumed to be considerably below that required to make truly substantive contributions in value engineering because of the sporatic nature of their participation in VE. Consequently, it may not be sufficient to fully represent the government's interests in evaluating workshop results. Without thoroughly qualified agency personnel, there is some danger that value engineering workshop reports may become routinely produced and received documents, rather than the basic design improvement and cost effectiveness tools that they are.

7. Consideration should be given to architect and engineer fee structures to provide incentives for VE. At present the VE workshop is seen as somewhat of an imposition on the architect or engineer who is under pressure to to complete a design at cost on schedule. This needs to be changed to make VE seen as the positive contribution to the design process it is. Within the consideration of fees and contracting procedures, some attention should also be given to the expanded use of VE during the construction phase in the sense of evaluating cost saving construction operations. Although a cost sharing mechanism now exists for savings made during construction, VE at this stage of the process of completing a building is not given the emphasis it is in the design phase, yet the design of the means of construction has just as much potential for cost saving evaluation as does the building design itself.

In conclusion, it may be noted from the case study examinations that the value engineering process is an adequate and operationally effective method to achieve cost savings in construction projects. It is perhaps also the only workable process now available. But as the lists of areas for further study that appear in all the case studies indicate, there is need to further concentrate and refine the process. It is probably not useful to extend the time of workshops as the 40 hour period is no doubt the most feasible to insure full participation. Rather the methodology needs to be tightened up to eliminate routine appraisals and to better accommodate intangible judgements in the cost evaluation process.

VALUE ENGINEERING WORKBOOK

40 hour VE WORKSHOP

conducted for

ALGERNON BLAIR, INCORPORATED

MONTGOMERY, ALABAMA

on the

FEDERAL OFFICE BUILDING

JACKSON, MISSISSIPPI

By:

Value Engineering Company
2550 Huntington Avenue
Alexandria, Virginia 22303

Date: JAN 6, 1976

Team No. 4

APPENDIX

Report of VE Team 4: Study of electrical components. Taken from the "Report on the 40-hour Value Engineering Workshop Conducted in Jackson, Mississippi" by Value Engineering Company, Alexandria, Virginia. This report is presented to show a typical workshop report and to illustrate the analytical and creative steps used in the VE process.

I INTRODUCTION

A 40-hour Value Engineering (VE) workshop was conducted during the week of January 5 through 9, 1976 in Jackson, Mississippi. The workshop was conducted for Algernon Blair, Incorporated of Montgomery, Alabama on the federal office building to be located in Jackson, Mississippi. The workshop was conducted by Value Engineering Company of Alexandria, Virginia. The VE instructors were Glen D. Hart and Edward J. Nichols whose resumes are shown in Appendix A.

A total of 21 personnel participated in the study. Four teams were formed to study the following areas:

Team 1: Mechanical, including HVAC, plumbing, and fire protection.

Team 2: Structural and Exterior Wall including foundation and ICB.

Team 3: Interior Construction, including finishes and floor system.

Team 4: Electrical

Team personnel and firm affiliation are tabulated in Appendix B.

A brief description of the building as designed is as follows:

Gross square feet of building - 396,804.

Number of floors - 15 plus one basement floor.

Construction - Monolithic cast-in-place concrete structure with facing. Combination mat foundation and spot footings or drilled caissons. Variable air volume cooling system. Underfloor raceway system for power and telephone systems. ICB system.

Total cost - $19,413,132 minus 909,640 (special and general conditions) minus 1,080,742 (escalated costs) equals $17,422,750.

A summary of the results of the VE study is presented below. Team workbooks are included in Appendix C.

Life cycle costs were calculated using a building life of 40 years, interest at 10% per annum, and with electrical energy inflating at 6% per annum.

II SUMMARY OF VE PROPOSALS

Team I: <u>Plumbing</u> - The original plumbing system required that roof drains be cast iron and that all domestic cold water piping be insulated. The domestic hot water was to be a hot water heater with return line pumps.

It was recommended that PVC pipe be used for the roof drain risers only and that any horizontal vans remain cast iron. It is also recommended that all domestic cold water pipe in chases not be insulated as condensation is no real problem in these areas. The system for domestic hot water is recommended to be a hot water heater at each floor without recirculation.

Instant Savings	$	45,446
LCC Annual Savings		3,679

Team I: <u>HVAC</u> - The original system was a VAV system in the interior spaces providing a reasonably priced scheme for good cooling control with reduced fan HP and load diversity.

Hot water perimeter heating provides minimum energy usage when supplied with heat rejected from the chilled water machinery.

Double bundle water chilling equipment provides simultaneous heating and cooling for the same energy input.

Economizer cycle and auxiliary heating maintains control of low temperatures.

It was proposed that the VAV system in the interior spaces function as in the Basic System.

Perimeter heating system changes from hot water radiation to direct distribution of interior heat to the perimeter by overhead ducts resulting in equipment and maintenance cost savings with insignificant increase in energy use.

Double bundle chillers are replaced with standard chillers at lower cost with insignificant change in energy use.

Economizer cycle provides economical cooling at low temperatures. Electric coils in perimeter heating units use energy only at very low temperatures.

Instant Savings	$	327,209
LCC Annual Savings		68,121

Team 2: Exterior Wall - The original concept was face brick with some sort of backup; either block or metal studs. The alternate proposed was a precast concrete exterior with a backup. The VE study indicated the alternate was the preferred system. It was recognized that possible inadequacies in the available cost information existed. However, it was recommended that precast concrete be strongly considered.

Instant Savings	$	226,422
LCC Annual Savings		23,153

Team 2: Parapet Wall - The original scheme had brick and block parapet wall to hide penthouse clad with metal panels. It was recommended to remove parapet wall and use brick on the penthouse wall.

Instant Savings	$	129,680
LCC Annual Savings		13,761

Team 3: Floor System - The as designed floor system consisted of two level duct system in the concrete slab. A raised access floor system on a structural concrete slab was recommended. Initial cost savings were identified as well as decreased construction time. Operating costs were lowered as maintenance cost increased only slightly.

Instant Savings	$	37,551
LCC Annual Savings		41,106

Team 4: Electrical - (Alternate #2) - The original cost estimate included a double duct embedded underfloor system for telephone and electric services at a cost of $362,400. If an access floor system alternate is accepted it will be necessary to provide home run conduit and junction boxes at a cost of $108,025, which would result in a net deduction of $254,375 for this electrical alternate.

Instant Savings	$	254,375
LCC Annual Savings		26,012

Team 4: Electrical - (Alternate #3) - The original cost savings estimate was based on the use of 2-2000 KVA power transformers. Actual VE design analysis indicated the use of 3-1000 KVA transformers with 3 - 15 KV primary feeders will satisfy the power requirements at a savings of $19,063.

Instant Savings	$	19,063
LCC Annual Savings		1,945

Team 4: Electrical - (Alternate #4) - Under the original cost estimate power transformers were furnished and installed by the contractor. This alternate assumes that power transformers will be furnished, installed and maintained by the local power company (Mississippi Power and Light Company). The instant contract savings of $73,813 are off-set by a rate reduction. A comparison of initial cost vs. savings is shown on worksheet No. 9 which indicates a break-even point prior to 22 years.

Instant Savings	$	73,813
LCC Annual Savings 1/		7,548

1/ Derived from worksheet 9 (showing alternate 4 computations as follows: $15,476 annual cost of alternate I minus $7,928 annual asset of original).

Team 4: Electrical - (Alternate #5) - This alternate considers the elimination of the emergency generator at an instant initial cost saving of $38,000. Team reviewed the proposed use of 3 - 15 KV feeders supplied from 3 separate substations by diverse underground routes, with 3 - power transformers in a spot network configuration with network protectors led to the conclusion that a very high reliability of service would result. The loss of one primary feeder would permit uninterrupted service with adequate capacity to serve the building. Under the remote possibility of the loss of a second primary feeder, adequate capacity is available to evacuate the building (with elevators) if required, because the 2 elevator banks are fed by separate sections of the main bus. The team was aware that this deviation from GSA criteria is not normally acceptable; however, the proposed design provides the equivalent of 3 separate primary feeder services and exceeded the teams interpretation of the NEC requirement for 2 separate supply sources.

Instant Savings	$	38,000
LCC Annual Savings		3,886
Total Instant Savings	$	1,151,557
Total LCC Annual Savings		189,211

The $1,151,557 total instant savings is 6.6% of the construction cost.

III OTHER AREAS WITH POTENTIAL SAVINGS

Team 2: It appeared that LCC favored the split elevator system (4 plus 4) over the 8 full height elevator system.

Cost of 8 full height system	$	1,150,000
Cost of split system (4 & 4)		943,000
Initial savings		207,000
LCC annual savings		31,113

IV AREAS SUGGESTED FOR FURTHER STUDY (WORKSHEET 12)

Team 2:

a. Operating versus fixed windows.
b. Half basement in lieu of full basement.
c. Eliminate basement
d. Study steel framing system over the less expensive concrete system with regard to construction time.
e. Background masking system versus noise from AC system.

TOTAL CONSTRUCTION COSTS		
PARA		GSF
QTY		
COST		
WORTH		

SUPPORT COSTS		
PARA		GSF
QTY		
COST		
WORTH		

Continued From Sheet 1

ORIGINAL ESTIMATE

07 CONVEYING SYSTEMS		
PARA		GSF
QTY		
COST		
WORTH		

Elevators		
PARA	LO	GSF
QTY		
COST		
WORTH		

PARA		GSF
QTY		
COST		
WORTH		

08 MECHANICAL		
PARA		GSF
QTY		
COST		
WORTH		

Plumbing		
PARA	FU	GSF
QTY		
COST		
WORTH		

HVAC		
PARA	TON	GSF
QTY		
COST		
WORTH		

Fire Protection		
PARA		GSF
QTY		
COST		
WORTH		

PARA		GSF
QTY		
COST		
WORTH		

09 ELECTRICAL		
PARA	GSF	GSF
QTY	396,804	
COST	5.24	
WORTH		

Service and Distribution		
PARA	GSF	GSF
QTY	396,804	
COST	0.36	
WORTH		

Lighting and Power		
PARA	GKWSF	GSF
QTY	396,804	
COST	3.70	
WORTH		

SPECIAL SYSTEMS		
PARA	GSF	GSF
QTY	396,804	
COST	1.04	
WORTH		

EMERGENCY POWER		
PARA	GSF	GSF
QTY	396,804	
COST	0.14	
WORTH		

10 GENERAL CONDITIONS & PROFIT		
PARA		GSF
QTY		
COST		
WORTH		

Overhead and Profit		
PARA	%	GSF
QTY		
COST		
WORTH		

Mobilization and General Condition		
PARA		GSF
QTY		
COST		
WORTH		

11 EQUIPMENT		
PARA		GSF
QTY		
COST		
WORTH		

Fixed Equipment		
PARA		GSF
QTY		
COST		
WORTH		

Furnishings		
PARA		GSF
QTY		
COST		
WORTH		

PARA		GSF
QTY		
COST		
WORTH		

12 SITE WORK		
PARA		GSF
QTY		
COST		
WORTH		

Site Preparation		
PARA	ACRE	GSF
QTY		
COST		
WORTH		

Site Utilities		
PARA		GSF
QTY		
COST		
WORTH		

Site Improvements		
PARA		GSF
QTY		
COST		
WORTH		

Worksheet 1
Sheet 2 of 2

GSA FORM 3287 (6/75)

FEDERAL OFFICE BUILDING, JACKSON, MS.   GROUP 4

ELECTRICAL WORK — 9 JAN 1976

TOTAL CONSTRUCTION COSTS		
PARA		GSF
QTY		
COST		
WORTH		

SUPPORT COSTS		
PARA		GSF
QTY		
COST		
WORTH		

Continued From Sheet 1

REVISED ESTIMATE WITH MAXIMUM DEDUCTIONS

07 CONVEYING SYSTEMS		
PARA		GSF
QTY		
COST		
WORTH		

Elevators		
PARA	LO	GSF
QTY		
COST		
WORTH		

PARA		GSF
QTY		
COST		
WORTH		

08 MECHANICAL		
PARA		GSF
QTY		
COST		
WORTH		

Plumbing		
PARA	FU	GSF
QTY		
COST		
WORTH		

HVAC		
PARA	TON	GSF
QTY		
COST		
WORTH		

Fire Protection		
PARA		GSF
QTY		
COST		
WORTH		

PARA		GSF
QTY		
COST		
WORTH		

09 ELECTRICAL		
PARA	GSF	GSF
QTY	396,804	
COST	3.06	
WORTH		

Service and Distribution		
PARA	GSF	GSF
QTY	396,804	
COST	0.17	
WORTH		

Lighting and Power		
PARA	GKSF	GSF
QTY	396,804	
COST	2.45	
WORTH		

SPECIAL SYSTEMS		
PARA	GSF	GSF
QTY	396,804	
COST	0.40	
WORTH		

EMERGENCY POWER		
PARA	GSF	GSF
QTY	396,804	
COST	0.04	
WORTH		

10 GENERAL CONDITIONS & PROFIT		
PARA		GSF
QTY		
COST		
WORTH		

Overhead and Profit		
PARA	%	GSF
QTY		
COST		
WORTH		

Mobilization and General Condition		
PARA		GSF
QTY		
COST		
WORTH		

11 EQUIPMENT		
PARA		GSF
QTY		
COST		
WORTH		

Fixed Equipment		
PARA		GSF
QTY		
COST		
WORTH		

Furnishings		
PARA		GSF
QTY		
COST		
WORTH		

PARA		GSF
QTY		
COST		
WORTH		

12 SITE WORK		
PARA		GSF
QTY		
COST		
WORTH		

Site Preparation		
PARA	ACRE	GSF
QTY		
COST		
WORTH		

Site Utilities		
PARA		GSF
QTY		
COST		
WORTH		

Site Improvements		
PARA		GSF
QTY		
COST		
WORTH		

Worksheet 1

Sheet 2 of 2

GSA FORM 3287 (6/75)

Worksheet 2

(Information Phase)

VALUE ENGINEERING TEAM STUDY

INFORMATION

PROJECT FEDERAL OFFICE BLDG, JACKSON, MS.

ITEM ELECTRICAL TEAM NO. 4

BASIC FUNCTION DISTRIBUTE ELECTRICITY DATE 9 JAN 1976

DESIGN CRITERIA:

THE ELECTRICAL SYSTEM WAS DESIGNED TO PROVIDE POWER AND LIGHT FOR THE BUILDING. THIS SYSTEM CONSISTS OF A MULTIPLE PRIMARY SERVICE AND SPOT NETWORK WITH NETWORK PROTECTORS; A SECONDARY DISTRIBUTION, 480 VOLT WYE FOR POWER AND FLOURESCENT LIGHTING; 208 VOLT WYE FOR GENERAL SERVICE, COMMUNICATION SYSTEM, FIRE DETECTION AND ALARM SYSTEM; AND EMERGENCY POWER DISTRIBUTION SYSTEM.

DESIGN HISTORY & BACKGROUND:

DESIGN CRITERIA INCLUDED GSA PBS-P3460.1B; PROJECT DESCRIPTION FOR PROJECT No 23-0083, A-E CONTRACT NO GS-04-B; PBS-P3410.1C HANDBOOK AND DIRECTIVE LETTERS, AND DRAWINGS PREPARED BY A-E AT THE CONCEPTUAL STAGE PRIOR TO PRESENTATION.

Team Members: LEIGH WATKINS III, J. W. GOODHEW, ME. KING, JACK SEXTON, PAUL H. SOMMERS

FUNCTIONAL ANALYSIS

PROJECT FEDERAL OFFICE BLDG, JACKSON, MS.

ITEM ELECTRICAL

BASIC FUNCTION DISTRIBUTE ELECTRICITY

DATE 9 JAN 1976

QUANTITY	COST CODE ~~UNIT~~	COMPONENT	FUNCTION VERB	FUNCTION NOUN		EXPLANATION	ORIGINAL COST	WORTH
	10.1	PRIMARY EQUIPMENT	CONNECTS	EQUIP	S		37,634	
	10.2	MAIN DISTR + PANELS	DISTRIBUTES	ELEC	B		31,605	30,000
	10.3	SUB-STA + TRANSFORMERS	REDUCES	VOLTAGE	S		73,813	
	10.4	POWER + LIGHTING DISTR	DISTRIBUTES	ELEC	B		345,988	345,000
	10.5	ELEC DEVICES + TRIM	CONNECTS	EQUIP	S		424,791	
	10.6	LIGHTING	FURNISHES	LIGHT	S		696,134	
	10.7	SPECIAL SYSTEMS	SENSES	COMBUSTION	S		409,197	
	10.8	EMERGENCY POWER SYSTEM	PROVIDES	ELEC	S		54,892	
	10.9	COMMUNICATION SYSTEM	PAGES	PEOPLE	S		5,199	
						TOTAL	2,079,253	375,000.

$C/W = 2,079,253 \div 375,000 = 5.5$

Worksheet 3
(Information Phase)

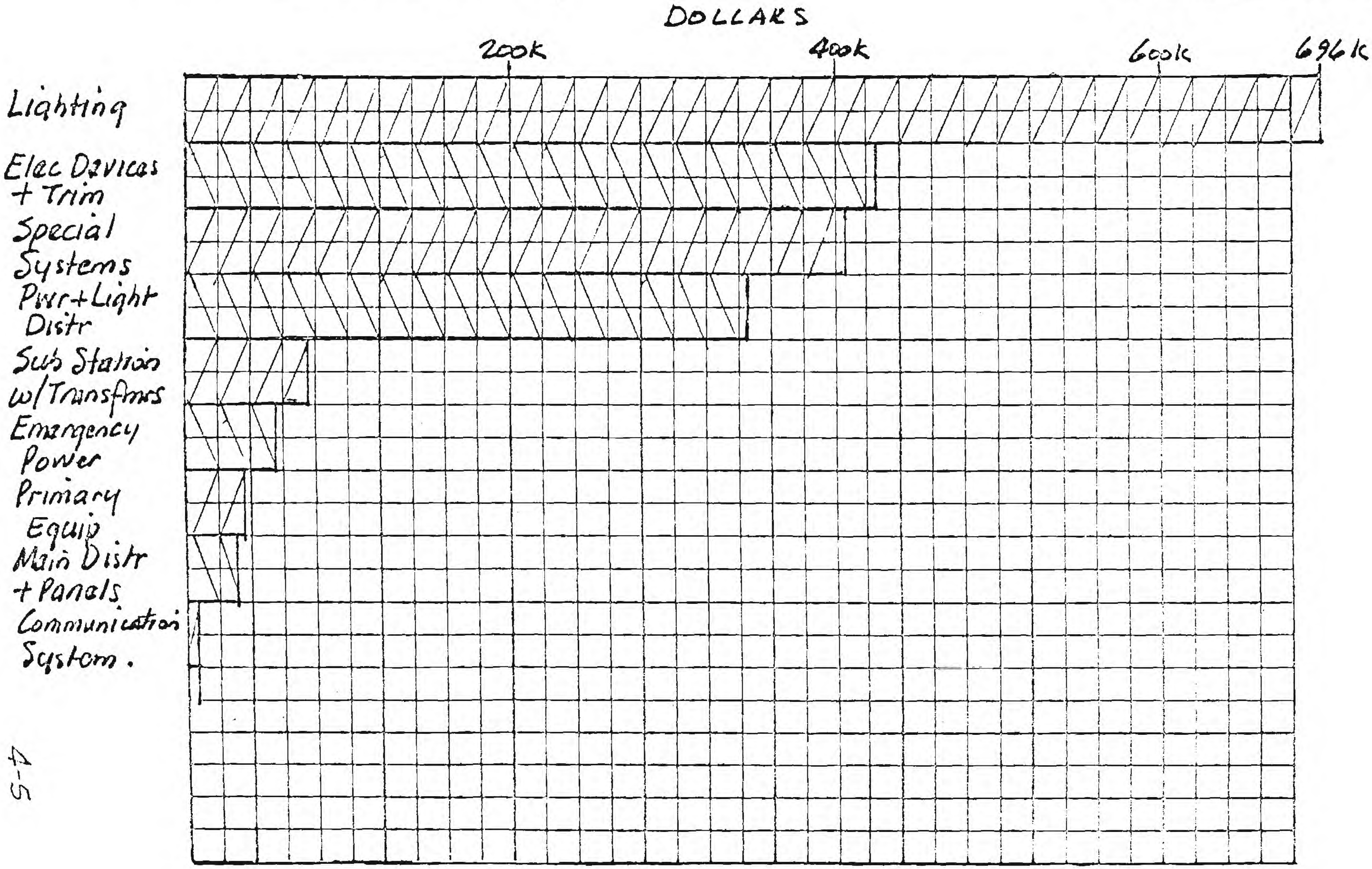
GRAPHICAL FUNCTIONAL ANALYSIS
(Prepare bar graph showing cost of each component.)

Project FEDERAL BLDG, JACKSON, MS.

Basic Function DISTRIBUTES ELECTRICITY

Item ELECTRICAL

Date 1-9-76



Worksheet 4
(Information Phase)

Worksheet 5
(Creative Phase)

VALUE ENGINEERING TEAM STUDY
CREATIVE IDEA LISTING

PROJECT FEDERAL OFFICE BUILDING, JACKSON, MS.
ITEM ELECTRICAL TEAM NO. 4
BASIC FUNCTION DISTRIBUTE ELECTRICITY

Uninhibited Creativity Date 9 JAN 1976

Don't Evaluate Idea - - - - Idea Refinement is Later

1. Intermediate Grade Conduit
2. PVC Conduit
3. Rigid Steel Conduit
4. EMT Conduit
5. Aluminum Conduit
6. Underfloor Raceway
7. Under access floor Raceway
8. Ceiling Raceway
9. Omit horizontal telephone conduit
10. XLPVC Conductor Insulation
11. Copper Conductors
12. Aluminum Conductors
13. Busway
14. Power Transformers - Quantity & size
15. Power Transformers by Ms Pwr Co
16. Dry-Type Transformers
17. Fusible Equipment
18. Circuit-breaker Equipment
19. Panel Boards
20. Panel Board Switching
21. Eliminate Emergency Generator
22. Battery operated emergency system
23. Diesel engine fire pump stand-by
24. 208 volt distribution
25. Power motor control centers
26. Integrated ceiling w/ fixtures by others
27. Alternate conventional lighting fixtures
28. Combustion Detectors in lobbies
29. Paging systems
30. Security systems
31. Lightning protection
32. Lamps
33. Clock system
34. Energy conservation
35. Load management
36. Load peaking
37.
38.
39.
40.

EVALUATION CHART

PROJECT FEDERAL OFFICE BUILDING, JACKSON, MS DATE 9 JAN 1976

ITEM ELECTRICITY TEAM NO. 4

BASIC FUNCTION DISTRIBUTE ELECTRICITY

Ideas Selected from Worksheet 5	Potential Advantages	Potential Disadvantages	Idea Rating
ALTERNATE NO 1 Integrated ceiling w/ fixtures by others.	Wanted by GSA Comfort Flexibility	High Cost Permits sound transmission	10
ALTERNATE NO 2 Access floor raceway using mini-type floor	Eliminated underfloor duct More flexibility Eliminates telephone conduits Saves Constr Costs Saves time	Higher cost for Architectural section.	10
ALTERNATE NO 3 Provide 3-1000 KVA Transformers in leu of 2-2000 KVA Transformers	Reduced cost Availablity of 3 Feeders More reliable service	More space More cost per KVA	9
ALTERNATE NO 4 Ms Pwr & Light Co furnishes transformers	Initial reduced cost	Higher rate	5
ALTERNATE NO 5 Eliminate Emergency Generator	Reduced cost	Less reliability	8
ALTERNATE NO 6 Substitute switch & fuse in leu of circuit-breakers for major distribution equipment	Reduced cost	Replace fuses.	4

Worksheet ~~13~~
(Development Phase)
JUDGEMENT PHASE

Weighted Constraints Chart

IDEAS \ Constraints	FIRST COST	RELIABILITY	FLEXIBILITY	O & M COSTS	SAVES TIME	SAFETY	TOTAL	RANK	
WEIGHT	10	10	9	5	8	4			
ALTERNATE NO 1									
INTEGRATED CEILINGS W/FIXTURES BY OTHERS	4/40	3/30	4/36	3/15	2/16	3/12	149	2	
ALTERNATE NO 2									
ACCESS FLOOR RACE WAYS	1/10	4/40	4/36	2/10	4/32	3/12	140	3	
ALTERNATE NO 3									
3 VS. 2 POWER TRANSFORMERS	1/10	4/40	4/36	3/15	2/16	3/12	129	4	
ALTERNATE NO 4									
MS PWR & LIGHT CO FURNISHES TRANSFMRS	4/40	4/40	4/36	4/20	4/32	3/12	180	1	LIFE CYCLE COST MAY ELIMINATE
ALTERNATE NO 5									
ELIMINATE EMERGENCY GENERATOR	4/40	2/20	2/18	4/20	3/24	1/4	126	5	
ALTERNATE NO 6									
SWITCH & FUSE VS CIRCUIT BREAKERS	3/30	2/20	1/9	3/15	2/16	3/12	102	6	

4---Excellent
3---Good
2---Fair
1---Poor

Project FEDERAL OFFICE BLDG, JACKSON, MS
Date 9 JAN 1976

COST BREAKDOWN WORKSHEET

NOTE: SHOW COST BREAKDOWN OF ORIGINAL DESIGN AND YOUR ALTERNATIVES - INDICATE REFERENCES USED TO OBTAIN COSTS

SYSTEM: SUBSYSTEM: UNIT:	UNIT QUANITY	UNIT COST	TOTAL COST
ORIGINAL ESTIMATE			
10.0 ELECTRICAL			
10.1 Primary Equipment			37,634
10.2 Main Dist + Panels			31,605
10.3 Sub Station + Transformers			73,813
10.4 Power + Lighting Distribution			345,988
10.5 Electric Devices + Trim			424,791
10.6 Lighting			696,134
10.7 Special Systems			409,197
10.8 Emergency Power System			54,892
10.9 Communication System			5,199
TOTAL ELECTRICAL			$2,079,253
ALTERNATE NO. 1			
10.6 INTEGRATED CEILING WITH			
FIXTURES BY OTHERS (This work			
is being furnished under the			
Architectural Section)			
DEDUCTIVE COSTS			
10.6 Deduct cost of fixtures	6200 EA	80.00	<-496,000>
ALTERNATE NO. 2			
10.7 ACCESS FLOOR RACEWAY USING			
MINI TYPE FLOOR			
DEDUCTIVE COSTS			
10.7 Eliminate underfloor ducts	302,000 SF	1.20	<-362,400>
ADDITIVE COSTS			
10.7 3/4" EMT Conduit	22,500 LF	1.05	23,625
4" Junction Boxes	300 EA	8.00	2,400
2" EMT Conduit	33,800 LF	2.00	67,600
12x12x4 Junction Boxes	450 EA	32.00	14,400
	302,000 SF	0.358	+108,025
NET DEDUCTION ALTERNATE No 2	302,000 SF	0.842	<-254,375>

COST BREAKDOWN WORKSHEET

NOTE: SHOW COST BREAKDOWN OF ORIGINAL DESIGN AND YOUR ALTERNATIVES - INDICATE REFERENCES USED TO OBTAIN COSTS

SYSTEM: SUBSYSTEM: UNIT:	UNIT QUANITY	UNIT COST	TOTAL COST
ALTERNATE NO. 3			
10.3 PROVIDE 3-1000 KVA TRANSFORMERS			
IN LEU OF 2-2000 KVA TRANSFORMERS			
DEDUCTIVE COSTS			
10.3 Deduct 2-2000 KVA Transformers	2 EA	36,906.50	<-73,813>
ADDITIVE COSTS			
10.3 Add 3-1000 KVA Transformers	3 EA	18,250	+ 54,750
NET DEDUCTION ALTERNATE NO3			<-19,063>
ALTERNATE NO.4			
10.3 MS. POWER & LIGHT CO FURNISHES			
POWER TRANSFORMERS			
DEDUCTIVE COSTS			
10.3 Deduct 2-2000 KVA Transformers	2 EA	36,906.50	<-73,813>
ALTERNATE NO. 5			
10.8 ELIMINATE EMERGENCY GENERATOR			
DEDUCTIVE COSTS			
10.8 Eliminate 200 KVA Generators			
including fuel tank system &			
transfer switch	L S	L S	<-38,000>
ALTERNATE NO.6			
10.2 SUBSTITUTE SWITCH & FUSE IN LEU			
OF CIRCUT BREAKERS FOR MAJOR			
DISTRIBUTION PANELS			
DEDUCTIVE COSTS			
10.2 Substitute switch & fuse for			
circut breakers	± 10½%	—	<-3,305>

COST BREAKDOWN WORKSHEET

NOTE: SHOW COST BREAKDOWN OF ORIGINAL DESIGN AND YOUR ALTERNATIVES - INDICATE REFERENCES USED TO OBTAIN COSTS

SYSTEM: SUBSYSTEM: UNIT:		ORIGINAL COST ~~UNIT~~ ~~QUANTITY~~	W/ALT No 3 COST	W/ALT No 4 TOTAL COST
SUMMARY OF ALTERNATES				
ALTERNATE NO 1	10.6	696,134	<496,000>	<496,000>
ALTERNATE NO 2	10.7	409,197	<-254,375>	<-254,375>
ALTERNATE NO 3	10.3	73,813	<-19,063>	
ALTERNATE No 4	10.3	(73,813)	——	<-73,813>
ALTERNATE NO 5	10.8	54,892	<-38,000>	<-38,000>
ALTERNATE NO 6	10.2	31,605	<-3,305>	<-3,305>
<MAXIMUM DEDUCTIONS>		1,265,641	<810,743>	<865,493>
REMAINING ORIGINAL UNCHANGED ESTIMATE		813,612		
TOTAL ORIGINAL ESTIMATE		2,079,253		
REVISED ESTIMATE WITH ALTERNATE No 3			1,268,510	
% REDUCTION			39%	
REVISED ESTIMATE WITH ALTERNATE No 4				1,213,760
% REDUCTION				42%
EXCLUDING ALTERNATE NO 1 WHICH IS ADDED TO ARCHITECTURAL SECTION, THE NET ELECTRICAL REDUCTION IS:			15%	18%
SEE VEP FOR PROPOSALS				

Life Cycle Cost Analysis

Worksheet 9 (Development Phase)

Project FOB - JACKSON, MISS Date 9 JAN 1976

System or Item TRANSFORMER TEAM NO. 4

ALTERNATE #4

			ORIGINAL	ALT. #1	ALT. #2
INITIAL COSTS	INSTANT CONTRACT	1. Base Cost			
		2. Interface Costs			
		(a)			
		(b)			
	COLLATERAL COSTS	3. Other Initial Costs			
		(a)			
		(b)			
		4. TOTAL INITIAL COST (2) 36,906 *	73813	0	
REPLACEMENT COSTS		LIFE-CYCLE EXPENDITURES			
		5. Year ___ @ ___ % Amount			
		Present Worth of Future Replacement Cost			
		6. Year ___ @ ___ % Amount			
		Present Worth of Future Replacement Cost			
		7. Year ___ @ ___ % Amount			
		Present Worth of Future Replacement Cost			
SALVAGE VALUE		SALVAGE VALUE			
		8. Year ___ @ ___ % Amount			
		Present Worth of Salvage Value			
		9. Year ___ @ ___ % Amount			
		Present Worth of Salvage Value			
TOTAL COST OF OWNERSHIP (LIFE CYCLE COST)		ANNUAL OWNING & OPERATING COSTS			
		CAPITAL RECOVERY OF THE TOTAL COSTS			
		10. Amortized Initial Cost @ 10 % 40 Year	7548	0	
		Initial Factor (.10226)			
		11. Capital Recovery of the Present Worth of the Replacement Cost			
		(a) Year			
		(b) Year			
		(c) Year			
		12. Annual Costs			
		(a) Maintenance			
		(b) Operations Note 1 (*)	15476	15476	
		(c)			
		13. TOTAL ANNUAL OWNING & OPERATING Note 2	(*) 7928	15476	
		14. Annual Salvage Value Credit (Amortized)			
		(a)			
		(b)			
		15. Net Annual Owning & Operating Cost			
		16. Annual Difference			
		17. PRESENT WORTH OF ANNUAL DIFFERENCE			
		18. Present Worth of line 15			

(*) See attached work sheets

SUPPLEMENT TO
WORKSHEET 9

9 JAN 1976

Sheet 1 of 2

NOTES:

1. There is a \$0.20 per kilowatt per month utility rate discount applicable if the GSA owns the transformers. This is estimated to be \$4000 annual savings. This savings is estimated to inflate at the rate of 6% per year.

This figure is a credit computed to be an annual rate of

$S = R\,(caf)$

$S = 4000\,(154.762)$

$S = 619{,}048$ total 40 yrs

$S = \dfrac{R\,(caf)}{40} = \dfrac{619{,}048}{40} =$

$= \$15{,}476$ annual

S = Future worth

R = Uniform Series of deposits

Caf = Compound amount factor (from tables 5%) 40 years

2. This figure represents an annual asset and the computation of the break even point if the transformers are owned by GSA is as follows:

Supplement for work sheet 9, Sheet 2 of 2 9 Jan 1976

Assumptions

P = \$73,813 to be invested at 10%

R = \$4000 savings per year to be inflated at 6% per year and invested at 10% for a total of 16% per year.

BREAK EVEN COMPUTATION		
YEAR	\$73,813 @ 10%, S = P(Caf)	\$4000 annual savings @ 16%, S = R(Caf)
10	73,813 (2.594) = \$191471	4000 (21.32) = 85286
15	73,813 (4.177) = 308,316	4000 (~~[illegible]~~ 51.659) = 206,638
20	73,813 (6.727) = 496,540	4000 (115.38) = 461,519
22	73,813 (8.14) = 600,837	4000 (~~[illegible]~~ 157.415) = 629,660
40	73,813 (45.259) = 3340702	4000 (2360.75) = 9,443,028

P = Cost of transformers, initial investment

R = Uniform series of deposits, yearly utility savings

n = number of years

Caf = Compound amount factor (Single payment or Uniform Series as applicable)

40 year projected savings 9,443,028 - 3340702 = \$6102

VALUE ENGINEERING PROPOSAL

PROJECT F.O.B. JACKSON, MS. DATE 9 JAN 1976

ITEM ALTERNATE No 1. TEAM NO. 1

Summary of Change (Brief Description of "before" and "after".)

ALTERNATE No. 1: The original cost estimate was based on the use of one (1) 2 lamp fluorescent fixture per 25 S.F. The I.C.B. ceiling design includes fixtures and our electrical cost estimate has been reduced by $ 496,000. An equivalent fixture cost should be included in the I.C.B. ceiling cost estimate.

ESTIMATED COST SUMMARY (ATTACH COST ESTIMATES IF NECESSARY).

LINE NUMBERS REFER TO WORKSHEET # 8.	No. of Units	Unit Cost	Total $
A. Original . . . (~~Total Initial Line 4~~) ALT. 1			696,134
B. Proposed . . . (~~Total Initial Line 4~~) ALT. 1			200,134
C. Initial Savings . . . A-B			496,000
D. Life Cycle Costs Annual Savings Line 16 . . .			N/A
E. Present Worth of LCC Annual Savings (Line 17)			N/A

Percent Savings Instant (C ÷ A) 71%

Percent Savings LCC, Annual (D ÷ line 15 of original design) ________

VALUE ENGINEERING PROPOSAL

PROJECT FOB JACKSON MS. DATE 9 JAN. 1976

ITEM ALTERNATE No. 2 TEAM NO. 4

Summary of Change (Brief Description of "before" and "after".)

ALTERNATE No. 2; The original cost estimate includes a double duct imbeded underfloor system for telephone and electric services at a cost of $ 362,400. If an access floor system alternate is accepted it will be necessary to provide home run conduit and junction boxes at a cost of $108,025. which would result in a net deduction of $ 254,375. for this electrical alternate.

ESTIMATED COST SUMMARY (ATTACH COST ESTIMATES IF NECESSARY).

LINE NUMBERS REFER TO WORKSHEET ~~1~~8

	No. of Units	Unit Cost	Total
A. Original. . . (~~Total Initial Line 4~~) ALT. 2		$ 409,197	$ 409,197
B. Proposed. . . (~~Total Initial Line 4~~) ALT. 2		154,822	254,375
C. Initial Savings. . . A-B		254,375	154,822
D. Life Cycle Costs Annual Savings Line 16. . .		N/A	N/A
E. Present Worth of LCC Annual Savings (Line 17)		N/A	N/A

Percent Savings Instant (C ÷ A) 62% 38%

Percent Savings LCC, Annual (D ÷ line 15 of original design)

VALUE ENGINEERING PROPOSAL

PROJECT FOB JACKSON MS DATE 9 JAN. 1976

ITEM ALTERNATE No. 3 TEAM NO. 4

Summary of Change (Brief Description of "before" and "after".)

ALTERNATE No. 3: The original cost estimate was based on the use of 2 - 2000 KVA power transformers. Actual VE design analysis indicated the use of 3-1000 KVA transformers with 3 - 15 KV. primary feeders will satisfy the power requirements at a savings of $ 19,063.

ESTIMATED COST SUMMARY (ATTACH COST ESTIMATES IF NECESSARY).

LINE NUMBERS REFER TO WORKSHEET 8

	No. of Units	Unit Cost	Total
A. Original. . . (~~Total Initial Line 4~~) ALT. 3		$ 73,813	~~$ 73,813~~
B. Proposed. . . (~~Total Initial Line 4~~) ALT. 3		54,750	~~19,063~~
C. Initial Savings. . . A-B		19,063	~~54,750~~
D. Life Cycle Costs Annual Savings Line 16. . .		N/A	~~N/A~~
E. Present Worth of LCC Annual Savings (Line 17)		N/A	~~N/A~~

Percent Savings Instant (C ÷ A) 25%

Percent Savings LCC, Annual (D ÷ line 15 of original design)

VALUE ENGINEERING PROPOSAL

PROJECT FOB JACKSON MS DATE 9 JAN. 1976

ITEM ALTERNATE No. 4 TEAM NO. 4

Summary of Change (Brief Description of "before" and "after".)

ALTERNATE No. 4: Under the original cost estimate power transformers were furnished and installed by the contractor. This alternate assumes that power transformers will be furnished, installed and maintained by the local power Company (Missippi Power & Light Co.) The instant contract savings of $73,813. are off-set by a rate reduction. A comparison of initial cost vs savings is shown on worksheet No. 9 which indicates a break-even point prior to 22 yrs.

ESTIMATED COST SUMMARY (ATTACH COST ESTIMATES IF NECESSARY).

LINE NUMBERS REFER TO WORKSHEET ~~9~~ 8	No. of Units	Unit Cost	Total
A. Original . . . (~~Total Initial Line 4~~) ALT. 4			$ 73,813
B. Proposed . . . (~~Total Initial Line 4~~) ALT. 4			0
C. Initial Savings . . . A–B			73,813
D. Life Cycle Costs Annual Savings Line 16 . . SEE ATTACHED			N/A
E. Present Worth of LCC Annual Savings (Line 17) WORK SHEETS			N/A

Percent Savings Instant (C ÷ A) 100%

Percent Savings LCC, Annual (D ÷ line 15 of original design)

VALUE ENGINEERING PROPOSAL

PROJECT FOB JACKSON MS DATE 9 JAN. 1976

ITEM ALTERNATE No. 5 TEAM NO. 4

Summary of Change (Brief Description of "before" and "after".)

ALTERNATE No. 5: This alternate considers the elimination of the emergency generator at an instant initial cost saving of $38,000. Our team review of the proposed use of 3 15 KV. feeders supplied from 3 separate substations by diverse underground routes, with 3-power transformers in a spot network configuration with network protectors led to our conclusion that a very high reliability of service would result.

The loss of one primary feeder would permit uninterrupted service with adequate capacity to serve the building. Under the remote possibility of the loss of a second primary feeder, adequate capacity is available to evacuate the building (with elevators) if required, because the 2 elevator banks are fed by separate

VALUE ENGINEERING PROPOSAL

PROJECT FOB JACKSON MS DATE 9 JAN. 1976

ITEM ALT. NO. 5 CONT'D TEAM NO. 4

Summary of Change (Brief Description of "before" and "after".)

sections of the main bus. We are aware that this deviation from GSA criteria is not normally acceptable - however the proposed design provides the equivalent of 3 separate primary feeder services and exceeds our interpretation of the NEC requirement for 2 separate supply sources.

ESTIMATED COST SUMMARY (ATTACH COST ESTIMATES IF NECESSARY).

LINE NUMBERS REFER TO WORKSHEET ~~?~~ 8	No. of Units	Unit Cost	Total
A. Original. . . (~~Total Initial Line 4~~) ALT 5		$ 54,892	
B. Proposed. . . (~~Total Initial Line 4~~) ALT. 5		16,892	
C. Initial Savings. . . A-B		38,000	
D. Life Cycle Costs Annual Savings Line 16. . .		NA	
E. Present Worth of LCC Annual Savings (Line 17)		N/A	

Percent Savings Instant (C ÷ A) 69%

Percent Savings LCC, Annual (D ÷ line 15 of original design)

Worksheet 11
(Presentation Phase)

VALUE ENGINEERING PROPOSAL

PROJECT FOB JACKSON MS DATE 9 JAN 1976

ITEM ALTERNATE No. 6 TEAM NO. 4

Summary of Change (Brief Description of "before" and "after".)

ALTERNATE No. 6: Consideration was given to the substitution of switch and fuse control for use in the main distribution panelboards. in lieu of circuit breakers at a saving of $ 3305. Our team does not recommend this change because of the small resultant savings compared with the disadvantages.

ESTIMATED COST SUMMARY (ATTACH COST ESTIMATES IF NECESSARY).

LINE NUMBERS REFER TO WORKSHEET ~~#~~ 8	No. of Units	Unit Cost	Total
A. Original. . . ~~(Total Initial Line 4)~~ ALT. 6			$31,605
B. Proposed. . . (~~Total Initial Line~~ 4) ALT. 6			28,300
C. Initial Savings. . . A-B			3,305
D. Life Cycle Costs Annual Savings Line 16. . .			N/A
E. Present Worth of LCC Annual Savings (Line 17)			N/A

Percent Savings Instant (C ÷ A) 10.5%

Percent Savings LCC, Annual (D ÷ line 15 of original design)

FEDERAL OFFICE BUILDING
JACKSON, MS

VALUE ENGINEERING REVIEW

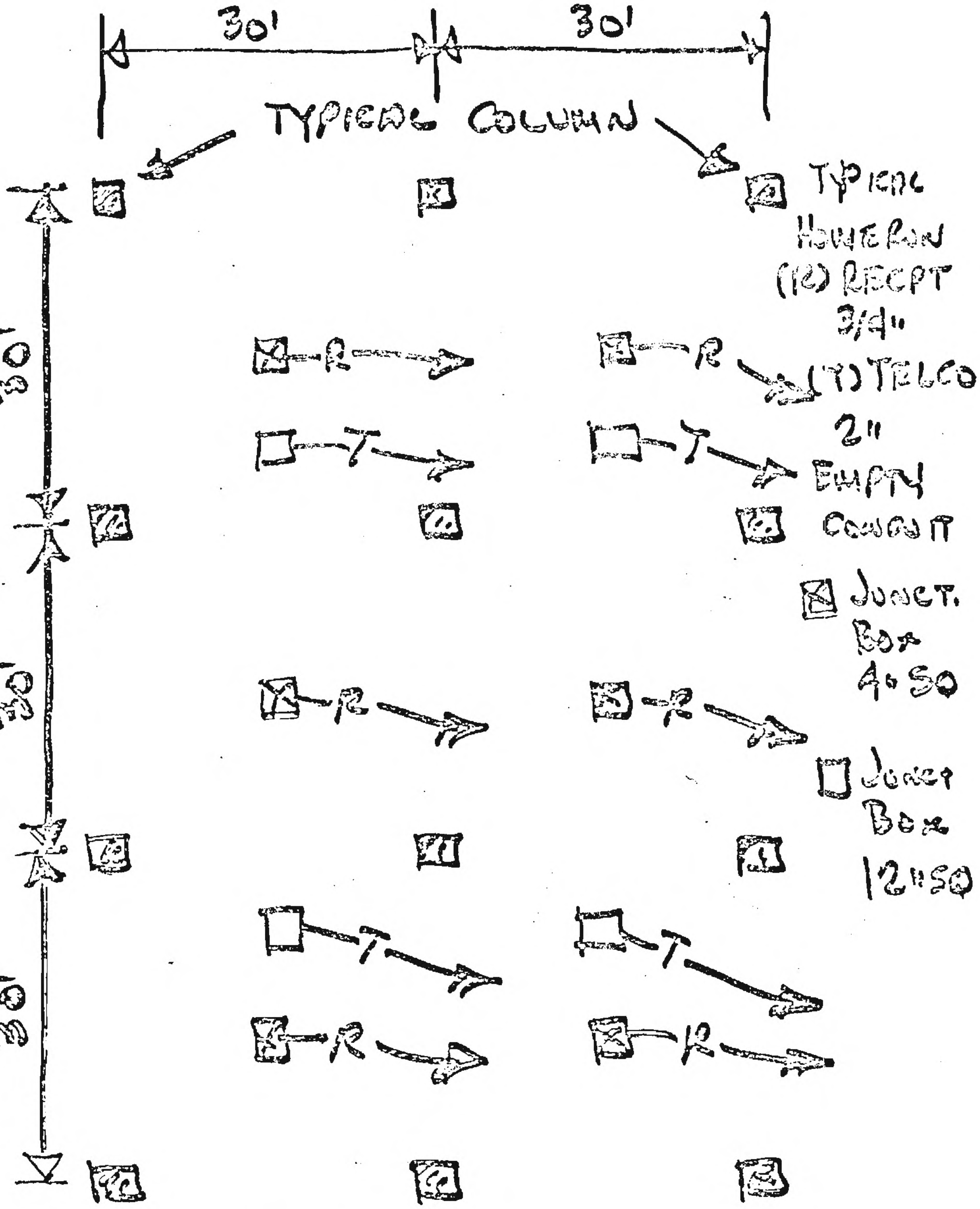
Worksheet 12

TEAM 4
9 JAN. 1976.

Idea Listing

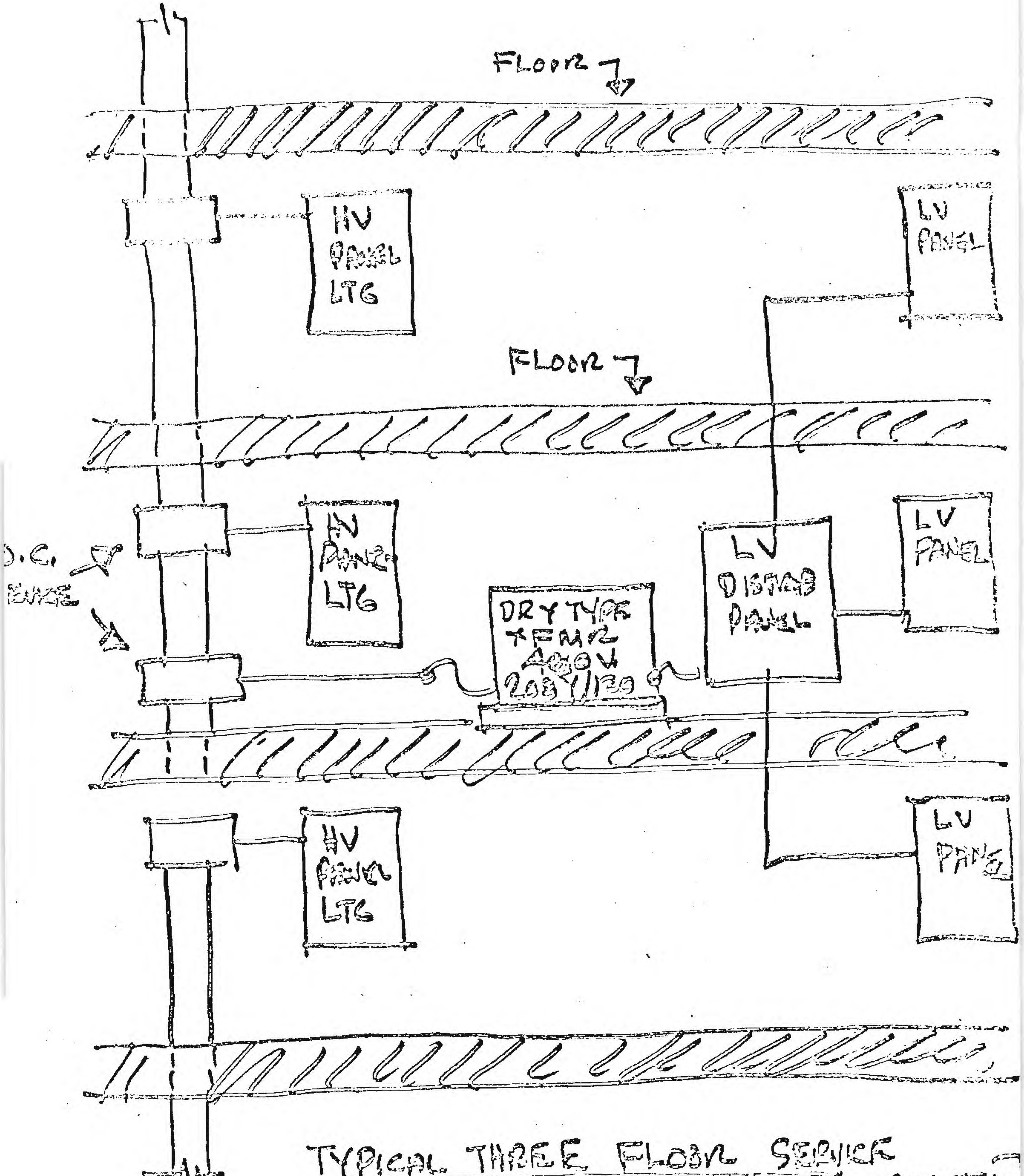
(Use this worksheet to list ideas which have potential but which you do not have time to pursue during this workshop.)

Description	Est. Potential Saving		Remarks
	Initial	Life Cycle	
Use of low energy lamps			Initial savings considered minor for these items.
Intermediate grade conduit			
PVC conduit			
Alum. conduit & conductors			
Energy conservation			LCC SHOULD BE MADE FOR THIS GROUP
Load management			
Load peaking			
Dry type power transf.			
Battery operated emerg. lights.			
Diesel engine driven fire pump			
Bldg. security system			SOME OF THESE ITEMS MAY BE INCLUDED IN FINAL CONTRACT DWGS.
Paging system combined w/ noise masking system			
Controlled clock system			
Bldg lightning protection			
Combustion detectors in lobbies			
208 volt distribution system			



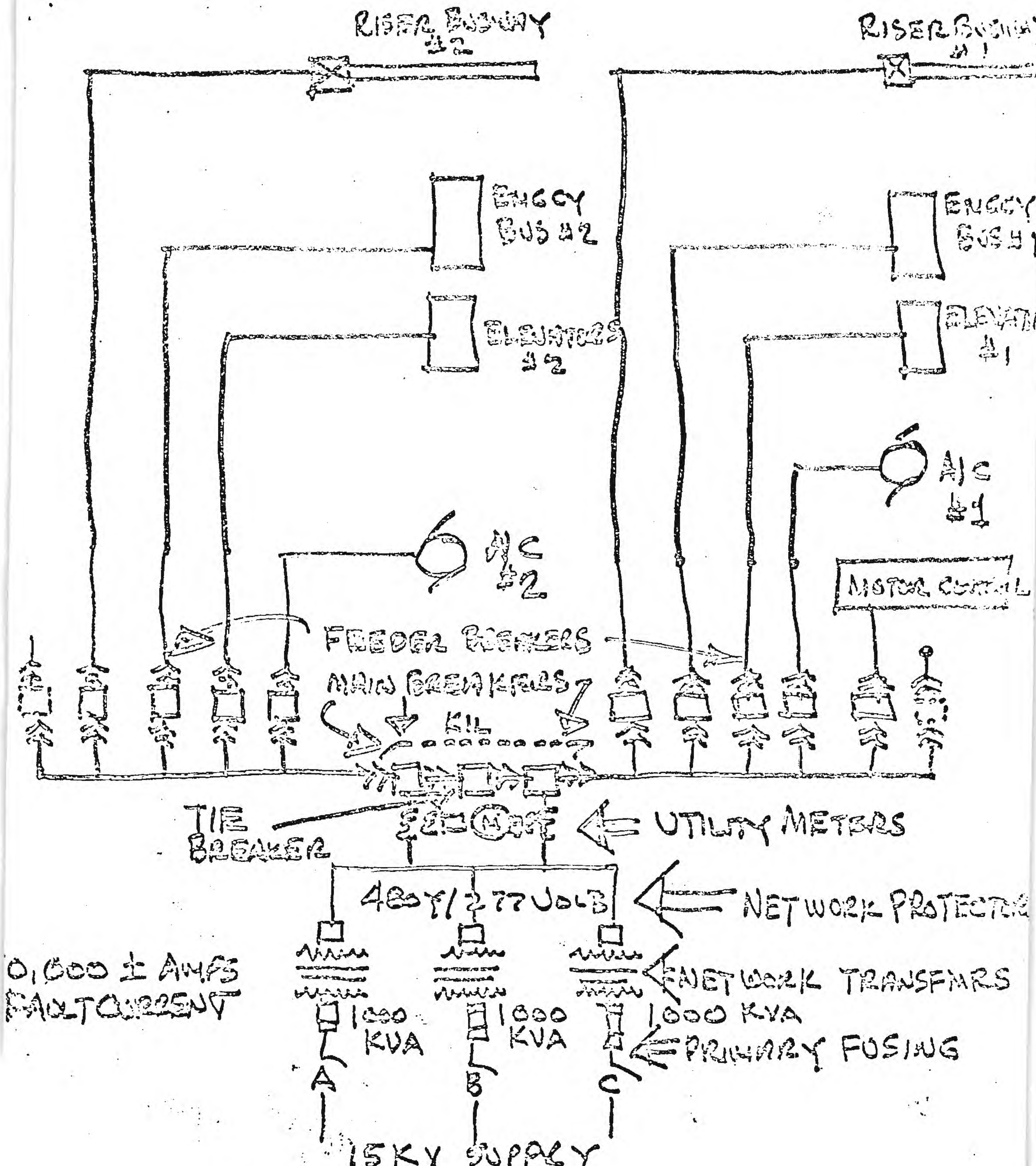
ALTERNATE #2
TYPICAL SIX (6) BAY
RECEPTACLE - TELCO DISTRIBUTION
BRANCH CIRCUIT - TELCO CONDUIT

CHART V



TYPICAL THREE FLOOR SERVICE RISER BUSWAY

CHART IV



POWER SYSTEM RISER

CHART III

4-25

VALUE ENGINEERING IN CONSTRUCTION

Course Notes and Classroom Teaching Outline

VE SEMINAR

Prepared for:

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ARCHITECTURE
ATLANTA, GEORGIA 30332

1981

VALUE ENGINEERING IN CONSTRUCTION

Course Notes and Classroom Teaching Outline

VE SEMINAR

Prepared for:

Environmental Protection Agency

By:

Richard J.L. Martin

May 1981

College of Architecture

Georgia Institute of Technology

The work herein was supported in part by a grant from the Environmental Protection Agency. All opinions, conclusions, or recommendations are those of the author and do not necessarily reflect the views of EPA.

VALUE ENGINEERING SEMINAR

24 Hour Instructor's Training Course Notes

Introduction

The Instructor's Course Notes comprise a course outline divided into three 8-hour periods and cited reference materials to assist the trained Value Engineering instructor in conducting training sessions. The references are drawn primarily from Government publications, and with certain exceptions are provided in their original publication format.

The outline is intended as a guide only and to provide a flexible teaching structure for the instructor to apply his own interpretation and emphasis. Graphic aids are considered supplemental and conditional to the classroom environment and instructor's discretion and therefore not provided in these course notes.

Teaching Outline and References

Day 1 (8 hours)

Introduction to Value Engineering

(1 hour) History and Background of Value Engineering

References:

1. GSA Value Engineering Handbook, Chapter 1, Part 2.

2. Introduction to Value Engineering/Analysis/Management, Section 1, Value Engineering in the Construction Industry; A. J. Dell'Isola.

3. "Value Analysis: New Concept Takes Root," Consulting Engineer, A. J. Dell'Isola.

4. "Value Engineering -- Weighing the Alternatives", Consulting Engineer, A. J. Dell'Isola.

(.5 hour) Value Engineering in Design and Construction.

References:

1. "Government View -- EPA Sees it Coming; GSA Says it's Here," Consulting Engineer.

2. GSA Value Engineering Handbook, Chapter 1, part 3, part 4.

3. Recommendations from Value Engineering Studies on Wastewater Treatment Plants, EPA.

(1 hour) Agency and Owner Requirements

Summary examples and illustrations from:

EPA
GSA
Other government agencies

References:

1. Value Engineering Case Studies and Formats for Proposals and Reports, EPA.

2. GSA Value Engineering Handbook, Chapters 2, 5, 6, Appendix B

3. "Architect-Engineer and Construction Manager," GSA Valve Management Services Handbook.

(1 hour) Value Constructs

Discussion of cost value added, and ethics concepts to establish determination of value.

References:

1. EPA Value Engineering Case Studies and Formats for Proposals and Reports, pp. 8-15.

2. EPA Value Engineering Workbook, pp. 1-15.

Methods and Skills Development: V.E. Tools

References:

1. GSA Value Engineering Management Workbook

2. EPA Value Engineering Case Studies and Formats for Proposals and Reports.

3. Introduction to Value Engineering, Sections 8, 9.

4. EPA Value Engineering Workbook, pp. 1-18.

(1.5 hours) Function Analysis

Methods and examples.

References:

1. GSA Value Engineering Handbook, Chapter 3, part 1.

2. EPA Value Engineering Workbook, pp. 26-31.

3. Introduction to Value Engineering, Section 2.

(1.5 hours) Data Gathering

Methods and examples.

References:

1. GSA Value Engineering Handbook, Chapter 3, p. 14.

2. EPA Value Engineering Workbook, pp. 18-21.

(1.5 hours) Creativity and Brainstorming

Methods and examples.

References:

1. GSA VAlue Engineering Handbook, Chapter 3, p. 19, parts 3, 4.

2. EPA Value Engineering Handbook, pp. 21-26.

3. Introduction to Value Engineering, Section 3.

Day 2 (8 Hours)

Methods and Skills Development, continued

(1.5 hours) Cost Models

Methods and Examples

Reference:

Introduction to Value Engineering, Section 4.

(1.5 hours) Life Cycle Costing

Methods and Examples

Reference:

Introduction to Value Engineering, Section 5.

(1.5 hours) Weighted Evaluation

Methods and Examples

Reference:

Introduction to Value Engineering, Section 6.

(1.5 hours) Presentation Methods

Examples

References:

1. GSA Value Engineering Handbook, Chapter 3, part 2, pp. 22-24.
2. EPA Value Engineering, pp. 31-37.
3. Introduction to Value Engineering, Section 7.

VE Applications

(2 hours) Case Study Analyses

40 hour workshop method

Day 3 (8 hours)

VE Applications

(4 hours) Case Study Analysis

Task Team Method.

System and component analysis methods

Reference:

1. Value Engineering Case Studies and Formats for Proposals and Reports.
2. Recommendations from Value Engineering Studies on Wastewater Treatment Works.
3. Value Engineering in Construction.

Summary and Review (4 hours)

(.5 hours) Summary of Value Engineering Purposes, methods and skills related to case studies.

(.5 hours) Review of Reference Materials

(1 hour) Discussion of Teaching Methods

(2 hours) Conducting V.E. Analysis

Setting up workshops: conduct model workshops

References:

1. EPA Value Engineering Workbook, pp. 9-18.
2. GSA Value Engineering Handbook, chapter 3, part 3.
3. GSA Value Management Workbook.

Closing

Discussion with course participants for suggestions for improving course. Review sheets may be distributed for written commentary at the discretion of instructor.

REFERENCE DOCUMENTS

Dell'Isola, Alphonse J., "Value Analysis: New Concept Takes Root," Consulting Engineer, November 1974, pp. 58-61.

Allen, Charles J. "Value Engineering -- Weighing the Alternatives," Consulting Engineer, November 1974, pp. 72-77.

Phett, John T., "The Government View: EPA Sees it Coming", Consulting Engineer, November 1974, pp. 66-69.

Roush, Larry F. "The Government View: GSA Says it's Here," Consulting Engineer, November 1974, pp. 70-71.

Martin, Williams, Gould. "Value Engineering in Construction -- Three Case Studies", Georgia Institute of Technology for EPA/GSA, June 1979.

"Value Engineering, Case Studies and Formats for Proposals and Reports", June 1977, GSA publication MCS-27. Available from General Services Administration, Centralized Mailing Lists Services, Building 41, Denver Federal Center, Denver, Colorado 80225.

"Recommendations from Value Engineering Studies on Waterwaste Treatment Works," September 1980, EPA publication MCD-69. Available from General Services Administration, Centralized Mailing Lists Services, Building 41, Denver Federal Center, Denver, Colorado 80225.

"Value Engineering Workbook for Consruction Grant Projects," July 1976, EPA publication MCD-29. Available from General Services Administration, Centralized Mailing Lists Services, Building 41, Denver Federal Center, Denver, Colorado 80225.

Dell'Isola, Alphonse J. "Value Engineering in the Construction Industry," Van Nostrand Reinhold Company, 1975.

"Value Engineering GSA Handbook," PBS P 8000.1. General Services Administration, Washington, D.C. 20405.

"Architect-Engineer and Construction Manager--Value Management Services," PBS P 8010.1. November 1976. Available from General Services Administration, Public Building Services, Washington, D.C. 20405.

"Value Management Workbook," GSA form 2760. Available from General Serviced Administration, Washington, D.C. 20405.

INSTRUCTOR'S NOTES
Day 1

INSTRUCTOR'S NOTES
Day 2

INSTRUCTOR'S NOTES
Day 3